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- 8-core, 16-thread AMD Ryzen 7 3800X CPU
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Upgrade to workstation-class performance PG. 70

SCREEN DREAMS

How display tech is radically improving PG. 44

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Alan Dexter

PLANNING IS INDISPENSABLE

PLANS DON'T always play out the way you intend. Like this month's eight-core cover build. It was originally designed to hit a budget of $1,500, but once we started building, we sailed straight over that price point. This was partly due to when we were building it—we put it together at the start of January, a notoriously tricky time, as pretty much everyone in the industry is in Las Vegas at CES (turn to page 10 to find out what went down in the desert).

Once we started piecing together our rig, we found ourselves upping the parts list to use better hardware. When you're dropping so much money on the CPU and motherboard, it makes sense to spend a comparable amount on the GPU, and here we decided to go with the current card of choice for 1440p ultra gaming: the GeForce RTX 2070 Super. Throw in some brilliant lighting, plenty of fans, and some top-drawer storage, and we found ourselves north of $2,000. You don't have to spend so much on your own build, obviously, but it's easy to see how spending can get out of hand when building a machine.

The eight-core cover build isn't the only system we've put together this issue, but, as it turns out, it is the most affordable. This is because for the second build, we took a fairly standard gaming machine and upgraded it to become a workstation. And when you're doing that, you can't scrimp on hardware, particularly as everything at this end of the market carries a serious price tag. You can find out the particulars of this upgrade on page 70.

One of the highlights from CES this year was the proliferation of interesting screen technologies, with the usual array of headline-grabbing huge screens, the push for 8K, high-refresh hitting 360Hz, and the likes of microLED promising a vibrant future for us all. But when will these technologies make it to our PCs? This issue we find out, discern what is actually important to our systems, and see what the next 12 months hold for our monitors (page 44).

Once you've got your system built, and you're manipulating your data on your high-res, high-refresh screen, you'll want to ensure that the data in question is protected. This month we show you how to do just that, whether that's protecting the data on your desktop, or where and how you store it elsewhere. We also show you how to securely obliterate your data, to make sure that no one can access it after the fact. Turn to page 34 to read more.

On the subject of security, this issue we also show you how to keep under the radar when you're surfing. Tor has been improving over the years, and now makes for a much smoother experience than it once did (page 60). We also show you how to get up and running with the free video-editing software OpenShot—it's a powerful tool, capable of some serious work, but getting started requires a little help, which is where we come in (page 56). On top of that, we've got plenty of other tutorials to get your teeth into, as well as a packed review section.

I hope you enjoy the issue!

Alan Dexter is Maximum PC's *executive editor and a punisher of hardware. He's been a tech journalist for over 20 years, and has no problem upsetting the PC industry as a whole.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

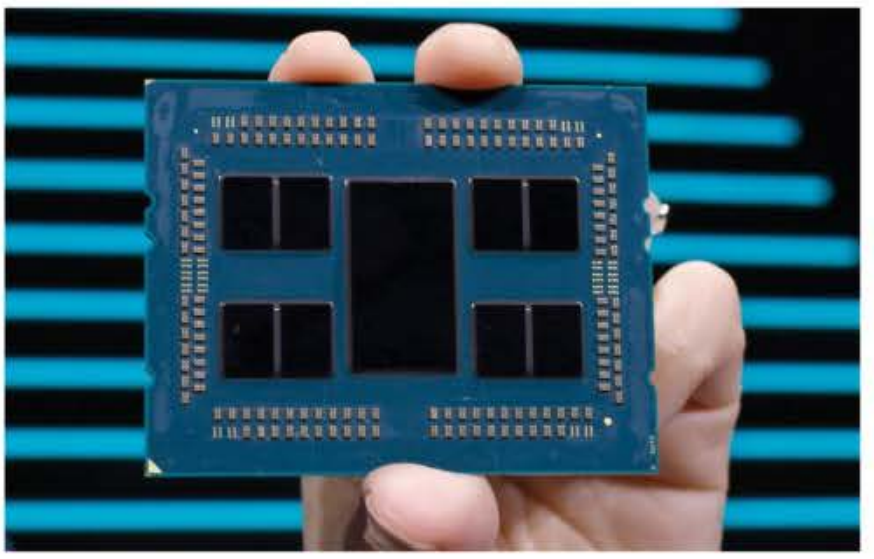
AMD's 64-Core Beast

New year starts with a bang for Team Red

AMD HAS ANNOUNCED the arrival of the "world's highest performance desktop and ultra-thin laptop processors." Big talk. First to the desktop: The new Threadripper 3990X is a beast, with 64 cores and 128 threads. It has a base clock of 2.9GHz, with a maximum boost rate of 3.4GHz. It shares the same basic design as the Epyc 7702P server chip, but with fewer memory channels and bumped speeds. It will drop into existing sTRX40 motherboards, with a quick BIOS update to optimize performance. Feeding it data means it needs 1GB per core as a minimum for complex tasks; 2GB is better, so you'll want 128GB of main memory to give it room to breathe. The TDP is still quoted at 280W, the same as all Threadrippers over 24 cores, but surely it must produce more heat? Not according to AMD.

Is this the world's highest performance desktop chip? It will be at many jobs, but not all. It's geared toward multithreaded tasks, video rendering, and such. AMD estimates it as being twice as fast as a 3970X. It's not a gaming chip, but it will do it, and fast. We'll find out how fast shortly. The Threadripper 3990X will cost $3,990. If that sounds like a lot, comparable 64-core Intel chips are twice that or more. AMD claims the 3990X will outperform two Xeon 8280s in selected tasks. For HEDT systems, this surely is the top of the tree for now. AMD made almost exactly the same claims when it launched the Threadripper 3970X last year; it wasn't wrong then, and this is even more of a jump.

Now to laptops. We have a new set of 4000 series mobile chips, the Renoir family. These run 7nm Zen 2 cores, with overhauled Vega graphics. We get the Ryzen 7 4800, Ryzen 5 4600, and Ryzen 3 4300U. All bar the 4300U come in both a "U" version, for low-power, ultra-thin devices, and an "H" version for fatter things geared to gaming and content creation. The top models are the Ryzen 7 4800U and 4800H, with eight cores and 16 threads. The 4800U has a base clock of 1.8GHz, and maximum boost of 4.2GHz. The TDP is 15W, but it can be configured from 10 to 25W by the laptop manufacturer, depending on cooling. The eight-core Vega graphics engine runs at 1,750MHz. The 4800H has a TDP of 45W, so you get a better base clock of 2.9GHz, but the same boost. The graphics engine has seven cores, and runs at 1,600MHz. AMD says the Renoir chips offer twice the performance per watt over the last generation: 70 percent due to the die shrink, and 30 percent due to better IPC (instructions per clock).



The new Threadripper 3990X: 64 cores of awesome.

We got a set of charts to substantiate AMD's claims. These show the 4800U beating Intel's Core i7-1065G7 by 28 percent on the 3DMark Time Spy benchmark; it repeats this feat over a selection of other productivity tests, and a selection of games. The 4800H is pitted against the Core i7-9750H, and it wins by a good margin, too. It also makes a comparison with Intel's desktop i7-9700K, which it beats as well—not by much, but this is against a desktop chip with over twice the TDP.

While the Threadripper 3990X will attract a lot of attention, the new laptop chips are an important step. The mobile market, particularly gaming laptops, has never been one of AMD's strong points. We've had to wait a while for the 7nm Zen 2 core to reach the mobile market, but it has put the company right back in the mix. AMD's Zen 2 chips are superb—dollar for dollar, they're hard to beat. But that final crown, being the world's fastest, always seems to be snatched away by Intel due to one thing: Can you build the world's fastest gaming rig using AMD CPUs? Sorry, AMD, but if you want to unequivocally be proclaimed the greatest, you need to beat Intel at what it has always done so well, and build the best desktop gaming chip. The Threadripper 3990X will give you the bragging rights for content creation and productivity; the 4800 looks good for the laptop title, too. One more belt to be undisputed champion. **–CL**

> That final crown, being the world's fastest, always seems to be snatched by Intel.

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GAME OVER FOR WIN 7

No more security updates

WINDOWS 7 has now entered the twilight world of "legacy" computing. Support from Microsoft officially ended on January 14. It is still possible to get security updates, if you're a business and prepared to pay. Initially, ESU, Extended Security Updates, were only to be available for Professional and Enterprise versions, but Microsoft has backtracked, and now promises to support "all business customers," as long as they have an Office 365 Business subscription. It's a yearly fee, and is planned to last three years. It costs $25 or $50 for the first year, depending on your business subscription. This doubles per year, so could be as much as $350 per machine for the full deal. After the third year, you really are on your own. One organization that wasn't ready was the German government, which still has thousands of Win 7 boxes, and has paid out $887,000 so far for extended support.

How many Win 7 systems are out there? More than you'd think. Most estimates are around the 25 percent mark. This is a lot of PCs, many millions, which makes it a tempting target for malicious types. It is possible that Microsoft will issue a security patch if something properly nasty happens; it did this for XP, five years after official support ended, when a worrying vulnerability was discovered.

The problem is that Windows 7 was so popular. It took Win 10 over four years to match its numbers, despite Microsoft's free update offer. This officially ended in 2016, but it didn't actually stop it, merely stopped publicizing it. You can still update your system from the "Download Win 10" section of the Microsoft site, as long as you have a valid license for Win 7 or later. Win 7 machines are going to be around for a long time, and while Microsoft would like you to upgrade, and doom-mongers will worry about being hacked, it looks as if it'll soldier on for years. This isn't a problem we'll have when Windows 8's time is up—it's used on under 4 percent of PCs. **–CL**

STEAM COMING TO CHROME

FANCY SOME GAMING ON YOUR CHROMEBOOK?

GOOGLE'S CHROME OS may have started life as little more than a browser, but the company has been building it into much more. Now it's going to add more fun too, with support for Steam. Getting this on to the millions of Chrome devices will bring Valve a healthy number of new customers. Steam already has a Linux client, so the project shouldn't be too complex. How good Chrome devices are going to be at playing games is another matter. They were initially intended as simple, cloud-based Internet devices. There are no Chromebooks with a discrete GPU, but there have been hints of AMD GPUs. However, the integrated GPUs are getting pretty good, and you won't be running demanding top-tier games on a Linux system anyway. All good news if you're stuck with a Chromebook for work or school—soon you'll be able to burn time playing "proper" games. **–CL**

FACEBOOK'S LIBRA STALLS

Wheels coming off Facebook's grand plans

FACEBOOK'S PLANS to launch a worldwide blockchain currency are slowly unraveling. The Libra Association is losing its major players at an alarming rate. PayPal dropped out first, then Visa, Mastercard, and Stripe left a week before the formal signup. The political pressure hasn't helped. A letter from two Senators to prospective members made this clear: "You should be extremely cautious," it read, and promised a high level of scrutiny. Now Vodaphone has pulled out, leaving just Uber and Lyft as known big names.

If nothing else, Libra has caused a stir in financial circles, and prompted much discussion at the World Economic Forum. The idea of a truly global stable digital currency is still sound, but it looks as if Libra may not be the vehicle to do it, or not in the way it had once hoped. It still has some good non-profit backers. One aim it has always had is as a financial service for the "unbanked" in developing nations; here it has a decent chance, but its grander schemes look to have fallen, or been pushed, to the wayside. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

2019: GOOD YEAR FOR PCs
Sales were up 2.7 percent, according to analysts IDC, ending seven years of contraction.

UNIVERSAL MEMORY
Scientists have theoretically found a way to build non-volatile memory that's as fast as DRAM.

DISNEY+ TOPS CHART
The Disney+ streaming app was the most downloaded app of Q4 last year. It also made $50 million in the first month—more than HBO has made any month.

TRAGEDIES

MICROSOFT FORCES BING
A new Chrome extension from Microsoft will force Office 365 ProPlus users to have Bing as the default search engine.

TESLA GOES TOO FAST
After 127 cases of "unintended acceleration," the NHTSA is considering an investigation.

MUSK VS. ASTRONOMERS
SpaceX's plans for a global network of satellites means bright streaks appearing across the world's telescopes.

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Intel's Graphics Card in Testing

AMONG INTEL'S OFFERINGS at CES was our first look at its jump into the discrete graphics card market. Intel is being cagey about the technical specs, but the first hardware, the Xe DG1, isn't built to show off Xe's eventual power. There are no power connectors for a start; it looks as if it can make do with the 75W the PCIe slot provides.

Early testers confirm that the card boots, runs, and has passed initial testing in-house; it has now to moved to distribution, along with a developer's kit, to third parties. An early Linux driver had it listed as "UHD Graphics Gen12 LP DG1," the same naming convention as the integrated graphics on the upcoming Tiger Lake CPUs, which would mean we're starting with a basic card with 96 execution units and a 1080p maximum.

The Xe family will come in three main groups: Xe-LP (Low Power), Xe-HP (High Performance), and Xe-HPC (High Performance Computing, the realm of supercomputers). All will use the same basic architecture, and employ "Xe link," an interconnect system that makes it possible to put, as Intel claims, "thousands of execution units" on a card. It will also features a scalable memory fabric on the more powerful versions. The key appears to be the ability to simply scale the hardware to match the task, whilst building it from fairly simple blocks based on Intel's UHD engine. The first commercial cards aren't expected before the summer. **–CL**

It's pretty at least. Intel's first manifestation of the Xe graphics project is a basic low-power card, but there is a lot more to come.

Twitter's Stolen Pictures

An AI company called Clearview, which claims to have the world's best facial recognition program, has been scraping images from Twitter, Facebook, and other sites without permission. It sells its services to the FBI, Homeland Security, and over 600 other law enforcement agencies. It has amassed over three billion images, and can track people back to the site a picture was taken from. Twitter has issued a "cease and desist" letter, and demanded that Clearview delete its images as it violates its developer agreement policy, which says content can't be used for surveillance. Current legislation is inadequate to deal with the rise of AI, and all the material it needs has already been posted. **–CL**

Chromium Edge Lands

Microsoft's Chromium version of its Edge browser has finished beta testing, and is available for download. It's been built using Google's Chromium open-source platform; Microsoft has finally ditched its own browser engine. Not surprisingly, it looks and feels a lot like Google Chrome, and supports all the same extensions. It also has a swish new logo. To keep some business users happy, it features an Internet Explorer mode, for "legacy" websites. It also blocks third-party cookies by default, something Google has promised to do, but not until 2022. It boasts that it's better than Chrome at managing system resources. It looks as though Microsoft finally has a first-rate browser. If you have Win 10, you'll be getting it as part of a Windows Update soon. **–CL**

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APPLE DROPS ENCRYPTED BACKUPS

FBI investigations made easier by change of plan

APPLE'S IPHONES PERIODICALLY make backups to Apple's servers, in case you lose or break your phone. Unlike your phone's internal data, the encryption key for these backups is held by Apple. Under a court order, Apple can retrieve the data for law enforcement agencies—it handed over the contents of 18,000 accounts to intelligence agencies in the first half of last year. Two years ago, Apple started working on a project to fully encrypt the backups with the user's own key. This was to making hacking more difficult. Then it, very quietly, didn't. Why? It transpires that the FBI, and others, weren't happy, and made that clear in private talks. Both parties are being tight-lipped about who forced who to do what, and when. Apple doesn't want to be seen as hindering the pursuit of dangerous criminals, and the FBI doesn't want to appear to demand that it can snoop on who it likes.

Apple isn't popular at the FBI. Its phones often hold materiel important to investigations, and it was the first to encrypt data on its phones, making it difficult to retrieve without the owner's encryption key. Apple has, depending on your point of view, been uncooperative or protective. In 2016, the pair had a spat over unlocking a suspect's phone. The FBI asked Apple to create a new version of iOS, which could circumnavigate the security features. Apple declined, and legal proceedings to force it to comply were instigated. These were dropped after the FBI got a third party to hack the phone, but was public about its disappointment with Apple. It transpires that Apple took the hint. According to "insiders," it was Apple's legal department that pulled the plug on the project. **–CL**

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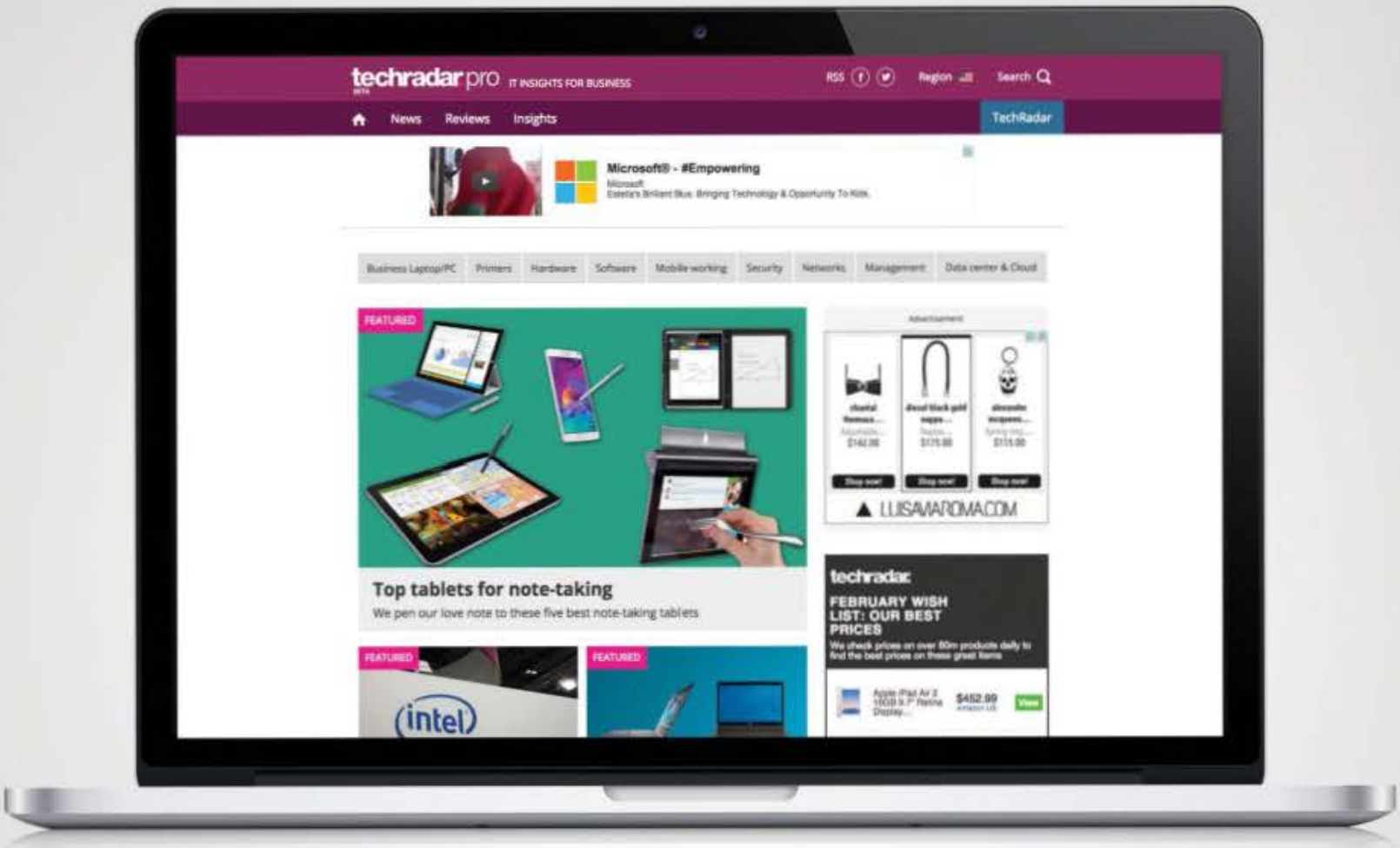

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Jarred Walton

TECH TALK

How Fast Can You See?

HOW FAST CAN THE HUMAN eye—and brain—see? And more particularly, do extremely high refresh rates help? These questions come up frequently in online discussions, and it gets awfully muddy when you start talking to experts on vision. Some note that the human nervous system works on electro-chemical pulses running at around 13Hz, others suggest 20–24Hz is sufficient, and still others push for as many hertz as possible.

Perhaps not surprisingly, Nvidia and its display partners fall into this latter category. This year, Asus and Acer will release 360Hz 1080p gaming displays targeted at esports professionals, using Nvidia G-Sync tech. But Nvidia isn't just pushing ever-faster refresh rates without some scientific backing, and at CES, I was able to go hands-on with these ultra-fast displays. Let me just say that any so-called expert who suggests lower refresh rates and frame rates don't matter for games has never actually played games. There is a huge difference between 30Hz and 60Hz. More importantly, there's a noticeable difference between 60Hz, 144Hz, 240Hz, and even 360Hz—in the right scenarios.

If you think the 50 percent increase from 240 to 360 won't matter much, I was right there with you. And seeing them side by side running a BlurBusters demo (http://tinyurl.com/wlb6eqw), the difference wasn't massive—but it was perceivable, and that's from a guy in his mid-40s without perfect eyesight.

Even more impressive to me was the game skill testing between 60Hz and 360Hz. Nvidia had two displays set up and running first-person shooter tests. The first involved sniping a bot down a hallway in a *CS:GO* map, where you only have a split second between seeing the bot jump through a doorway and shooting it. The problem is that input latency from the 60Hz refresh rate and frame rate narrows your reaction window to an absurd level. Out of 50 attempts, at 60Hz I was able to snipe the bot (which appears at random intervals) once—and I wasn't alone. Even the top esports pros were only connecting on about 20 percent of shots. Flip to the 360Hz display, and I jumped to around 80 percent hit rates, with pros getting closer to 100 percent.

> Flip to a 360Hz display, and I jumped to 80 percent hit rates, with pros getting closer to 100.

Asus will be one of the first to ship a 360Hz 1080p display.

It felt contrived, sure, but there's no denying input lag can make a difference in a competitive shooter. The second test was more realistic, using a custom *Rainbow Six Siege* test where you had to spin around and headshot a slowly moving foe as many times as possible in 45 seconds. At 60Hz, everything felt sluggish and I managed a score of 15, while at 360Hz, the difference was immediately obvious, and I scored 21 hits. I tried going back and forth between the two, and the scores were relatively consistent.

That's not to say that everyone should buy a 360Hz display as soon as they go on sale. But for highly competitive players, Nvidia's research indicates most pros improved in performance by 3–4 percent when moving from 240Hz to 360Hz in games like *CS:GO.* The caveat being: Of course it would be *CS:GO,* one of only a few shooters where 360fps is achievable.

If you're more into single-player, 360Hz isn't really a factor. I've tested dozens of games using the fastest hardware available, and only a few can break 240fps at minimum settings and 1080p using an i9-9900K and RTX 2080 Ti. None hit 360fps. Even so, we're not done yet, as there was talk of future displays targeting 1,000Hz. Or maybe we just go full-on *Star Trek* holodeck and call it a day.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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Alex Campbell

OPEN SOURCE

Keybase Is the Encrypted System You're Looking For

WHAT STARTED AS A SIMPLE public key registry is now an encryption powerhouse for all kinds of users. If you're looking for secure replacements for file sharing, cloud storage, chat, Git, or user authentication, Keybase probably has you covered. By making encryption easy, Keybase is looking to make communication and collaboration more secure.

I signed up for Keybase.io a few years ago. Back then, I saw the service as an innovative method to share PGP public keys. Since then, the upstart encryption application has expanded to cover several services well beyond its initial offering.

First off, I have never once used my PGP key for anything other than signing emails. Pretty Good Privacy—implemented with GnuPG or GPGTools and commonly known by its open-source moniker GPG—is one of the most powerful public key encryption tools available. Unfortunately, using GPG to encrypt text and files can be cumbersome.

Furthermore, proving the authenticity of a public key is problematic. When polling old key servers like that hosted at MIT, only the key fingerprint and email address can be used to authenticate a key. Keybase's methodology is different: Each user can use a number of social media accounts to authenticate their public key. With a simple set of keystrokes, one can encrypt a message to a Keybase user with their public key, even if they don't know the recipient's Keybase username.

If someone wanted to encrypt a message to me, they could use my Keybase username (alexcampbell) or my Twitter handle (accurrently@Twitter) via the command line. While this is nice, newer Keybase features make this process nearly obsolete. The Keybase File System (KBFS) works a lot like Dropbox, and creates mount points on your local system (generally at `/keybase` on Linux and OSX). If Alice wanted to encrypt a file to me, she'd simply place a file at the mount point `/keybase/private/alice,alexcampbell`, which is a folder that automatically encrypts all files placed within it with my and Alice's public keys, before being uploaded to Keybase's cloud storage. Alice can also have a private storage folder at `/keybase/private/alice`.

> The upstart encryption app has expanded to cover services well beyond its initial offering.

The kicker? Every Keybase user gets 250GB of free cloud storage, and any shared files only count against the original sharer's quota.

Keybase has encrypted user-to-user chat and a feature called Teams (a drop-in replacement for Slack), using the same public key encryption scheme.

Keybase now provides for encrypted private Git repositories, too; while GitHub has private repositories, the files in those repositories are stored unencrypted. If you have a personal diary or a collection of configuration files with secrets, Keybase's Git feature is an option.

Keybase also offers the ability to hold the Stellar cryptocurrency Lumens (XLM) in a wallet accessible via the Keybase app, making it simple and seamless to use the currency. A Stellar wallet is included as a proof of identity, so you can be sure a Stellar payment to Alice is going to Alice, not Bob.

The Keybase profile of co-founder Chris Coyne.

For now, Keybase is free to use. The project got a first round of funding from VC firm Andreessen Horowitz in 2015. While the software is open-source, Keybase has hinted at letting users pay for more storage or other enhanced services to sustain the business.

If nothing else, the 250 GB of free encrypted cloud storage is worth checking out Keybase.

A word of caution: While Keybase can create a private key online, always generate a GPG keypair on your own machine. The Keybase docs can help with that.

Alex Campbell is a Linux geek who enjoys learning about computer security.

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WHAT IS AVAXHOME?

AVAXHOME-

the biggest Internet portal, providing you various content: brand new books, trending movies, fresh magazines, hot games, recent software, latest music releases.

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Cheap constant access to piping hot media
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18 years of seamless operation and our users' satisfaction

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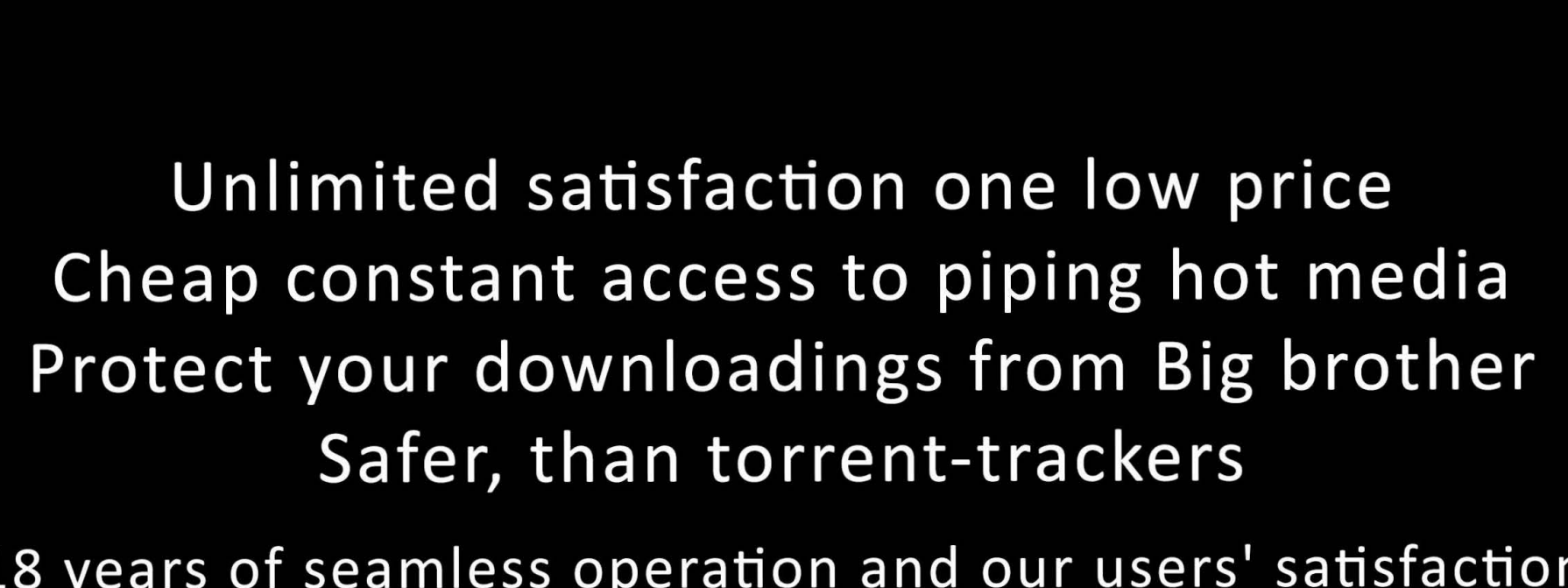

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THE LIST

THE BEST TECH FROM CES 2020

8

SAMSUNG Q950TS Samsung's new 8K TV has an invisible bezel that makes the display appear edgeless.

7

LENOVO YOGA 5G

Lenovo's big reveal at CES 2020 was the world's first 5G laptop, inventively called the Yoga 5G. It's a super-modern two-in-one laptop with a reported 24-hour battery life.

6

ASUS ROG SWIFT 360

Asus and Nvidia's new monitor touts G-Sync along with a blistering 360Hz refresh rate—the first of its kind.

5

ACER TRAVELMATE P6

Acer's latest addition to Intel's "Project Athena" laptop run, the TravelMate P6, is super-durable yet super-light, with a 10th-gen Intel CPU and 23 hours of battery life.

4

HP ELITE DRAGONFLY G2

A slick new laptop from HP, the Dragonfly G2 comes with a built-in tracker for Tile, the app that tracks the location of your valuables.

3

INTEL GHOST CANYON NUC

A tiny, barebones PC designed to be upgraded as much as you want. Its unique, compact form factor sets it apart from custom builds.

2

ALIENWARE CONCEPT UFO

No, it's not a Nintendo Switch, but this new portable gaming PC looks uncannily like the convertible console.

1

DELL CONCEPT DUET

A dual-screen laptop competitor to the upcoming Surface Neo, the Duet is a piece of technological magic. It's only in the concept stage right now, but we're intrigued.

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HEAD TO

BY **CHRISTIAN GUYTON**

Oculus Rift S vs. HTC Vive Cosmos vs. Valve Index

VR has come a long way. Some would argue it's not quite there yet (some members of the Maximum PC team, in particular), but it's hard to deny that the platform has made leaps and bounds in the past few years. Since Palmer Luckey broke the mold with the original Oculus Rift, several competitors have emerged, most prominently HTC's Vive and the more recent Valve Index. Oculus hasn't been resting on its laurels, though, and tethered VR clearly isn't dead—but which model out right now is the best for you? Let's break it down....

ROUND 1

Value

Despite its ludicrous $999 price, the Index sold out incredibly fast. Valve restocked, of course, but with *Half-Life: Alyx* looming on the horizon, it sold out again. The price has dropped somewhat since then, though, bringing it more in line with the $699 Vive Cosmos. The Rift S, though, clocks in at $399, feeling almost ridiculously cheap in comparison.

That significantly lower price doesn't come with any huge drawbacks either. Yes, the Rift S is the oldest of these three headsets, and it has a slightly lower resolution, but it still performs perfectly well when paired with a good VR-ready PC. The Rift S also has the lowest refresh rate of the trio, but only by a small margin. In a sense, you get what you pay for when it comes to VR, but the Rift S is undeniably good value.

That's not to say that the others are poor value for money, but paying more than 500 bucks for a VR solution in a market where all the big players are broadly comparable isn't a great proposition. Both the Index and the Cosmos were criticized on release for being overly expensive, and as long as there are eminently affordable options (such as Sony's best-selling PSVR), those criticisms will remain valid.

Winner: Oculus Rift S

ROUND 2

Controllers

All three VR platforms come with excellent, high-quality controllers. All have proper motion controls and similar button layouts, and the Rift S and Cosmos both utilize "inside-out" tracking systems that use cameras mounted on the headset itself to track the controllers. Full finger-tracking is a feature touted by the Valve Index, the only one to have controllers that properly wrap around the hand.

The controllers on the Oculus Rift S are particularly nice, using touch sensors on the buttons to simulate proper finger-tracking to reasonable effect. The number of games that use finger-tracking is relatively small, though, so it's unclear if this really gives the Index an edge. A few titles (such as Valve's Aperture Hand Labs tech demo) show it off nicely, to be fair.

In practice, we favor the Rift S controllers. The Cosmos controllers are very similar in design, but don't sit as comfortably in the hand, and are a bit heavier. The Rift S controllers are the lightest, but the buttons and triggers still feel firm and responsive. The Vive and Rift controllers both look a lot nicer than the weird, jagged Index knuckle controllers, too. Another win for Oculus, then.

Winner: Oculus Rift S

ROUND 3

Design

When we say "design," we're not just talking about aesthetics here. If we were, the winner would be the Rift S again; the Valve Index is pretty fugly compared to the other two, with the Rift S looking sleek and smooth in black, while HTC's latest headset is a truly sci-fi piece of hardware.

The Index might look weird and chunky, but the design extends beyond mere aesthetic value; in fact, given that you'll be strapping your chosen headset over your face, we would go so far as to say that appearance is irrelevant. Design extends to extraneous features like earphones; the Index is equipped with a pair of near-field speakers that are strapped to the headband, hanging just out of reach of your ears. It's a great design choice; zero contact means that extended sessions won't get uncomfortable, and the directional audio quality is phenomenal without cutting off all outside sound altogether.

The Cosmos headphones press against the ear, potentially making for sweaty lobes, while the Rift S has tiny built-in speakers that don't really measure up. Add in the high build quality of the Index (the cushioning is excellent, and the entire headset feels durable) and it's a clear win for Valve.

Winner: Valve Index

HEAD

From left to right: **The Oculus Rift S is the ultimate evolution of the groundbreaking original Rift. HTC's latest headset can be fitted with a wireless adapter. The Valve Index is the newest here.**

ROUND 4

Performance

It's difficult to benchmark tethered VR headsets, as they rely on a PC to power the games. Were we comparing standalone headsets, like the Oculus Quest, which use a headset-integrated processor, this category would likely be easier. As it stands, we're going to have to look at some other elements.

Eye display resolution first: The Oculus Rift S loses out straight away, with 1280x1440 per eye (or 2560x1440 total), while the Index and Vive Cosmos have 1440x1600 and 1440x1700 per eye respectively. The shift in resolution is noticeable between the Rift S and the other two, but the Index and Cosmos are pretty much indistinguishable.

The Index's two displays also have a leg up over the competition in two important areas: refresh rate and field of view. While the Rift S and Cosmos sit at 80Hz and 90Hz respectively, the Index packs a mighty 120Hz refresh rate, with an experimental 144Hz mode for some games. It can make a notable difference, although broadly speaking, as long as it remains above 80Hz, it shouldn't interrupt gameplay immersion. Lastly, the Index has an effective maximum FOV of 130 degrees—significantly more than the other headsets, which are around 110.

Winner: Valve Index

ROUND 5

Ease of Use

As much as we like the Valve Index, it isn't going to win this section. Oculus and HTC have been in the VR game for a while now, and they've learned from their mistakes; in this case, it's the introduction of inside-out tracking that really leaves the Index in the dust. You've still got to set up base stations around your room, and enter the floor height of the room you're playing in, then use the controllers to mark the four corners of the room, then have Steam on your PC calculate a usable play area.... It's a convoluted process that feels outdated and clunky.

The Rift S, however, simply shows you a spooky gray-tinted video feed of your surroundings using the external cameras, and has you paint out a play area using one of the controllers. It takes seconds, and the boundaries fade in unobtrusively if you get too close to the edges.

The Vive Cosmos is almost as good, automatically mapping out walls and corners in your play area to use as markers. It takes even less time than the Rift S, but it's not infallible; if the exterior cameras lose track of the controllers, it takes frustratingly long to reorient them, and low lighting conditions can prove ruinous.

Winner: Oculus Rift S

And the Winner Is...

We have to hand it to Facebook, it knew what it was doing when it bought Oculus in 2014. The VR giant has come a long way since the original Kickstarter campaign for the first Rift prototype, constantly at the forefront of what makes VR great.

It's true, the Rift S might be the least powerful piece of hardware on show here, but it's not enough for a VR headset to simply have the latest eye displays. It has to be affordable, and it has to have the support of developers. Oculus was the first on the scene to modern VR, garnering it a decent chunk of the market right off the bat, and the company has kept as much of that as it could.

Yes, the Valve Index is the high-end VR headset right now. The quality of the headset itself is undeniable, and anyone who says that *Half-Life: Alyx* will be best experienced on a different platform is kidding themselves. But the Rift S is far better value, much easier to use, and when it comes down to it, the VR experience is much the same regardless of your choice of headset. All we'd advise is getting a good pair of earphones.

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DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Fan Controllers
> Kick-Ass PC Tweaks
> Browser Backups

Faulty Fan Controllers

In May 2018, I built a new PC and put it in a Rosewill Thor V2 case. This is a great case, but the documentation is sorely lacking, as it makes no mention of how to hook up the fan speed controllers—in fact, neither they nor the two Molex plugs are mentioned at all. I was never able to determine if the speed controls were working, but the fans were on, so let it go for 18 months.

Over Thanksgiving, I opened the case to install a second SSD. I then took the entire case apart to address other problems and ended up disconnecting all the fans and going online for advice. I found a post advising me to hook up controllers A1 and A2 to the top and rear fans, and B1 and B2 to the front and side fans. But there was no mention of where to hook up the two front-panel Molex connectors. I went ahead and hooked them up daisy-chain style to the Molex connectors powering the fans they're supposed to control. But I still don't see any indication that the controllers are working. So, can you tell me how to hook these things up?

–Charles K. Ballard

Your fans need to be powered via the fan speed controller, not directly from the power supply unit.

THE DOCTOR RESPONDS:
Your problem is that you've got power going directly to the fans. The fans shouldn't be plugged into your PSU, but connected to the fan speed controller using a three-pin cable, rather than the four-pin Molex connector. Assuming the fans don't come with a three-pin connector, you need to buy one Molex-to-three-pin fan adapter, like that at www.newegg.com/p/N82E16812189119, for each fan. Plug in your fan's Molex connector at one end, then plug the three-pin connector into the sockets behind the front plate on the case. Finally, plug the two Molex power connectors for the fan speed controllers into the PSU. This means all power to the fans is distributed via the controllers, enabling you to adjust the flow of electricity to—and therefore speed of—each set of fans.

Delay Hibernating

I've often got a large file to synchronize with Dropbox, so I want to delay shutting down my PC for 15 minutes while it completes. That's easy with

```
C:\Windows\System32\shutdown.exe -s -t 900
```

Is there a way to apply a similar delay with hibernate? Replacing "-s" with "-h" doesn't do the trick, whether the target is System32 or SysWOW64. **–Jay Frank**

THE DOCTOR RESPONDS:
There's no way of setting a "-t" flag with the hibernate command, but a workaround is to run the hibernate command after using "timeout" to provide the desired delay. The following works from the command prompt, not the PowerShell:

```
$ timeout /t 900 /NOBREAK > NUL && shutdown /h
```

The "&&" flag allows you to cancel the hibernate command during the delay by pressing Ctrl-C inside the command prompt. If you'd like to jump to the hibernate command instead when pressing Ctrl-C, use:

```
$ timeout /t 900 /NOBREAK > NUL || shutdown /h
```

Dual Displays

My current PC is a 2012 Dell Inspiron 560 with Win 10 Enterprise, running two displays: a Dell IN2020M and a Samsung SE310 S22. I'm looking at purchasing the $350 Kick-Ass PC from your August 2019 issue and would like to know whether I need to add a dual-monitor graphics card to use the two displays. If I do, which would you recommend? Also, would I struggle to incorporate my two optical drives—one of which is Blu-ray? **–Bill Boyer**

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↘ submit your questions to: doctor@maximumpc.com

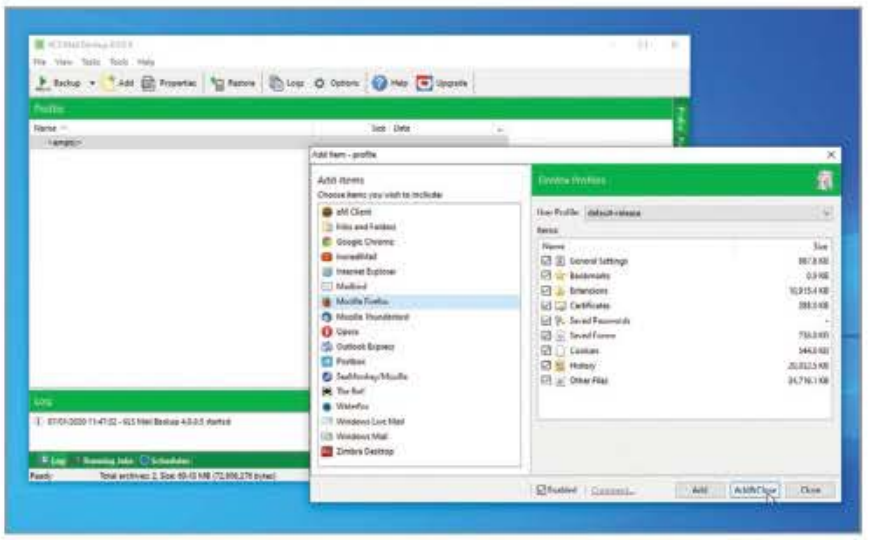
THE DOCTOR RESPONDS: The budget PC we recommended was built around the AMD Ryzen 3 2200G processor, with ASRock's B450M Steel Legend our choice of motherboard. These days, onboard graphics can easily handle two HD displays like yours—the key is making sure your motherboard has the right outputs. Luckily, the B450M Steel Legend fits the bill—you can plug your Samsung into its HDMI port, and the Dell into the DVI port.

Regarding your Blu-ray drive, you're correct: The Corsair SPEC-05 case isn't designed to accommodate any optical drives, so you need to look elsewhere. You don't have to look too far, though: Corsair's SPEC-01 gaming case supports up to two 5.25-inch optical drives, and at $60, won't break the bank.

Backing Up Firefox

For years I've performed a fresh reinstall of Windows every 12–18 months on my PC and my wife's. I've always used a program called FEBE to image my Firefox browser. It worked great backing up open tabs, passwords, and bookmarks. Now FEBE no longer supports the latest Firefox version, and I can't find anything that does the same thing. Do you know of any FEBE replacements? I have two hard drives on both computers, and it was always a piece of cake reinstalling using the second hard drive as a place for all my software, licenses, and FEBE backup. **–Ray Fletcher**

THE DOCTOR RESPONDS: FEBE effectively ceased development over three years ago, right around the time Firefox dropped support for so-called legacy extensions. We're surprised you've been able to keep it going for so long. Going forward, one solution is to make use of a Firefox account, which enables you to sync all your Firefox data to the cloud, making it easy to set up again post reinstall. It also keeps things backed up as you work.



KLS Mail Backup can back up and restore your entire Firefox profile.

This approach isn't perfect, though—you must re-log into all your old online accounts after reinstalling Windows, plus restoring tabs is awkward and incapable of restoring your setup exactly the way it was. It certainly requires a bit more work and doesn't meet your own criteria of "reinstalling it to a position as if I just sat back down from only getting a cup of coffee."

Thankfully, there is a fuss-free way of backing up and restoring your Firefox profile to its previous state: KLS Mail Backup (www.kls-soft.com/klsmailbackup). Despite the name, it's designed to back up browsers, too.

After launch, click "OK" and select Mozilla Firefox from the "Add Items" list. Click "User Profile" to select your profile ("default-release" on our PC), leave everything checked, then click "Add & Close." You're shown the "Properties" dialog, where you can choose your backup destination—we also recommend selecting "Scheduler" to have it backed up periodically to provide additional protection against data loss. Once set up, click "Save & Run," allowing KLS Mail Backup to close Firefox to complete the backup job.

After reinstalling Windows, reinstall Firefox, and let it launch. Close it, then reinstall and launch KLS Mail Backup. Click "Close" at the profile setup and properties screens in turn, then choose "File → Open Archive" to find and select the backup you took just prior to reinstalling Windows. Click "Next," then "Restore." Job done: Firefox restores your profile to the point when it was last backed up.

We did struggle with some add-ons not appearing in the browser toolbar after restoration, but we think this was because Bitdefender forced a couple of plugins on to us. Go to "about:addons" where you should find the add-ons are all present: Disable and re-enable each in turn to restore them to the toolbar.

Securing Booksonic

I've tried following Nick Peers's advice in the February issue to set up a secure external connection to my Booksonic audiobook server using a LetsEncrypt Docker container, but so far all I've managed to do is set up an insecure connection using the subfolder technique. Is it possible to set up a secure connection instead? **–Hans Schwartz**

THE DOCTOR RESPONDS: You may find everything is already in place—if your audiobook server is running on the same IP address as your LetsEncrypt Docker instance, try going to https://domain.com/booksonic instead of http://domain.com:4040/booksonic in your browser—if all is well, you should be able to log in securely.

If this isn't the case, you can still achieve what you want. First, your Booksonic server needs exclusive access to port 443 on whatever machine (virtual or physical) it's running, which means it requires its own unique IP address. Second, you need to set up a suitable subdomain pointed to your home public IP address—"booksonic.domain.com" for example—for your apps to use to dial in remotely.

Your nginix/LetsEncrypt server needs to create an SSL certificate for booksonic.domain.com following the advice in the previous guides—if you're running it through Docker, for example, recreate the container, making sure to add booksonic to the list recorded in the SUBDOMAINS value. Finally, if you've not done so, you need to set up a port-forwarding rule in your router pointing port 443 to the IP address of the nginx server. This allows the server to redirect connections on port 443—regular https:// connections—to your Booksonic server on the booksonic.domain.com without affecting any other services that also use port 443 through the reverse proxy, such as a personal web server.

Browse to the "/config/nginix/proxy-confs" folder and download a copy of the "airsonic.subdomain.conf.sample" file to your PC. Open it in a text editor and save it as "booksonic.subdomain.conf." Edit the "server_name airsonic.*;" line so it reads "server_name booksonic.*;" then point "set $upstream_airsonic" toward your Booksonic server's IP address—for example:

```
set $upstream_airsonic 192.168.0.5
```

Save the file, upload it back to "proxy-confs," then restart the LetsEncrypt container.

Test the connection works by going to https://booksonic.domain.com/booksonic in your browser—you should see a secure connection inside and outside your home network. Once verified, update your apps to point to the new https URL, and you're good to go.

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GAMING POWERHOUSE

We set out to assemble a powerful eight-core system for gaming. Break out the LEDs!

BY CHRISTIAN GUYTON

WE STARTED OUT with a budget for this. Our initial idea centered around an eight-core CPU and a Radeon RX 5700 XT, but this was soon scuppered by the arrival of a beautiful, mirror-fronted RTX 2070 Super FE at the *Maximum PC* office. The price rose, and our CPU/GPU cost ratio skewed, so up we went from a Ryzen 7 3700X to the 3800X—sticking with our eight-core plan.

Of course, a gaming PC needs more than just a good CPU and powerful graphics. We needed an X570 motherboard to support that chip, and those don't come cheap. The addition of memory and a non-stock cooler drove us over our original budget. And so, this build shifted; no longer a sensibly priced machine, but a gaming powerhouse. Treasure this rare glimpse into the inner workings of *Maximum PC,* where the temptation to throw money at a build is ever-present.

We didn't go too overboard; this isn't a Dream Machine, after all. So, 16GB of high-speed RAM and lots of storage—3TB, to be exact. If you can't download your whole Steam library, what's the point? High-speed 2.5G Ethernet and Wi-Fi 6 connectivity from our mobo mean that downloads shouldn't even take too long (if your Internet connection is up to scratch).

We're also opting for the full "gamer" treatment, which means RGB lighting, of course. We've got some specific fans in for that, courtesy of Fractal Design—a few to replace the existing fans in our Thermaltake case, and a couple of extra ones to improve the case airflow. Our CPU likely won't be bearing the bulk of work done by this PC—with a gaming rig, auto-overclocking for the GPU is important—so overall airflow is more significant than dedicated CPU cooling.

All five case fans we're using are translucent plastic with RGB LEDs inside, and our CPU cooler also features RGB fans. The memory uses RGB lighting, too; the motherboard is LED-free, but its black-and-gray finish will contrast nicely with whatever color scheme we decide to use. We're also including a 30cm RGB lightstrip from Asus's Republic of Gamers line, to provide the ultimate in case illumination, although this is an optional addition that we found buried in our gear cupboard and decided to use, so feel free to skip it. Our case has large tempered glass side panels, so the guts of this machine will be fully on display.

That means cable management and general tidying, but we'll get to that. We'd like this to be a PC that you can show off to your less technologically capable friends; a monument to the fact that you are the superior system builder as well as the superior gamer. Let's get to it!

! PG. 30 STEP-BY-STEP

POWERHOUSE PC INGREDIENTS

PART		STREET PRICE
Case	Thermaltake A500 TG	$250
Mobo	MSI MEG X570 Unify	$300
CPU	AMD Ryzen 7 3800X	$373
CPU Cooler	Cooler Master MA610P	$50
GPU	Nvidia GeForce RTX 2070 Super FE	$620
Memory	16GB (2x 8GB) Corsair Dominator Platinum RGB DDR4-3600	$170
PSU	760W Fractal Design Ion+ 760P 80+ Platinum	$125
Boot Drive	1TB Corsair MP600 SSD	$200
Storage Drive	2TB Seagate Barracuda ST2000DM001	$37
Fans	Fractal Design Prisma AL-14 (2x) and AL-12 (3x)	$110
Operating System	Windows 10 Home	$100
TOTAL		**$2,335**

POWERHOUSE INGREDIENTS

CPU

AMD RYZEN 7 3800X $373

A recent price drop makes the 3800X even more attractive. Yes, in a powerful build, there's potential to use the 12-core Ryzen 9 3900X, but that would result in a significant price increase for only marginally better gaming performance. The 3800X is now less than $50 more expensive than the 3700X, but brings a significant increase to standard operating frequency while packing the same eight-core architecture. Fully unlocked for overclocking, PCIe 4.0 support for superfast SSD transfers, and a low 105W TDP all serve to sweeten the deal.

CPU COOLER

COOLER MASTER MA610P $50

Surprise! We're using air cooling for this build. You already knew that, of course, because you looked at the cover of this magazine first, like a normal person. There's no stock coolers to be seen here, though; the Cooler Master MA610P is a stylish air cooler, with a tall heatsink flanked by two snap-on fans. In addition, it comes with brackets that enable it to be attached to either Intel or AMD platforms (no Threadripper, though). The two fans are uniquely shaped to give the MA610P a slick rounded form that eschews the blockiness of many air coolers.

! PG. 30 STEP-BY-STEP

RAM

CORSAIR DOMINATOR PLATINUM RGB 16GB (2x 8GB) DDR4-3600 $170

We've championed the Dominator Platinum before, and this time is no different; the Platinum RGB runs fast and looks good. The solid metal exterior and 12 addressable RGB LEDs per stick scream "high-end," and the performance is among the best available. We contemplated a 32GB kit, but increasing memory capacity provides diminishing returns for gaming performance. We're keeping the frequency high, letting our Ryzen CPU get the most out of the 3,600MHz memory speed.

MOTHERBOARD

MSI MEG X570 UNIFY $300

If we're using a third-gen Ryzen processor, we want the right board. That means the X570 chipset, and X570 mobos were prohibitively expensive after Ryzen 3000's initial release. Now, you can snag an X570 mobo for under 200 bucks, but we're not cheaping out; MSI's MEG X570 Unify is perfect, providing great all-around performance. Plenty of heatsinks mean that this system will stay cool, while Wi-Fi 6 and 2.5G LAN provide the best Internet connectivity for online gaming.

GPU

NVIDIA GEFORCE RTX 2070 SUPER FE $620

The RTX 2070 Super Founders Edition looks even better than older FE cards, with a mirrored center panel to reflect RGB lighting. With 8GB of GDDR6 video memory and a boost of 1,770MHz, this is a super-powered graphical heart for our rig. It supports native resolutions up to 8K, it's VR-ready, and it's prepped for ray-tracing action. It is a bit pricey compared to models from other manufacturers, though, so feel free to stick with your preferred brand.

PSU

760W FRACTAL DESIGN ION+ 760P 80+ PLATINUM $125

A powerful build such as this needs a good power supply. Fractal Design might have only recently ventured beyond the case kiddie pool and dipped its toes into the PSU shallows, but the Ion+ series are excellent power supplies. Rated to 80+ Platinum for maximum performance and longevity, this model provides 760W for our system, which should be more than enough, leaving a little room for expansion if needed. The RTX 2070 Super needs 215W and the processor draws 105W, which means there's still plenty of overhead. Oh, and it's fully modular, too, saving us from having to bundle excess cables away beneath the PSU shroud.

SSD

CORSAIR MP600 1TB $200

Start writing your complaints now, folks. We kid, of course; we know we've been recommending the MP600 in just about every third-gen Ryzen build we've made, but we promise we're not shills for Corsair. The fact is that PCIe 4.0 M.2 drives are still relatively uncommon; only five major manufacturers have released their versions, and the MP600 remains the best value. Plus, it's a great drive; this system should be hitting close to that glorious 5,000MB/s transfer rate, loading games faster than the eye can see (because, well, you can't "see" data).

FANS

FRACTAL DESIGN PRISMA AL-14 AND AL-12 $110

That's two 140mm fans and three 120mm fans, to be precise. Some of these will be replacing the existing case fans; one 120mm at the rear, and two 140mm Prismas at the front of the case. It's a shame that they'll be hidden by the solid metal front plate, but these fans are bright, shining through to illuminate the rest of the case. We're going to be putting the other two 120mm fans on the case ceiling, providing some extra cooling, while also adding further lighting to this build with six addressable LEDs per fan.

HDD

SEAGATE BARRACUDA 2TB ST2000 DM001

$37

It's an older hard drive, sir, but it checks out. This early Barracuda (that's right, not "BarraCuda") HDD brings 2TB of storage space on a hefty 7,200rpm rectangle, perfect for storing all your movies and images. Really, just about any 7,200rpm hard drive from a reputable manufacturer should do the work; the drive we're using is several years old, but uses the same SATA connection as any other modern HDD. Seagate's products are good quality, although if you're buying this drive online, be aware that it may not include a SATA connector cable. There should be one included with the motherboard, however.

! PG. 30 STEP-BY-STEP

CASE

THERMALTAKE A500 TG $250

If you're the gym-shy type, you won't be by the time you're done with this build. The A500 TG from Thermaltake is somehow simultaneously gigantic and super-sleek, an obelisk of dark brushed aluminum and tempered glass that weighs over 30 pounds. Lifting and positioning this case is not a task for the faint of heart—remember, bend at the knees, and get someone to help if you need it. Weight aside, this case is excellent, constructed to an extremely high standard and equipped with multiple drive trays and plenty of space for the extra fans we're going to be using.

BEGIN THE BUILD

Make sure all of your components are to hand, prep your building space, and ready your tools; it's time to get building!

1 EXCESS EXTRACTION

LET'S BEGIN with a case stripdown. Start with the side panels, which open with a latch and a magnetic clasp, and can then be lifted off their hinges. Be careful with the glass panels! Put them in the box until you're finished. The metal front panel pops off with a bit of force. The top panel comes off the same way, but needs more care to avoid damaging the front I/O. We left that one on for now, as it only needs removing when installing the case fans later. Remove the drive cages above the PSU shroud, as we're not using them and they'll hamper airflow. You can remove the vertical GPU mount, too. Lastly, remove the case fans, and donate them to a pal with a dusty case.

4 MOTHERBOARD MOUNTING

TIME TO PUT that board inside the case. Often, we'd recommend fitting an air cooler before doing this, but the MasterAir MA610P is a big cooler that'll get in the way of our fan installation. Before you mount the board or get stuck in with fans, though, take a look at the various screwpoints and standoffs around the case. You might want to file some of these down; during our build, blood was spilled when an errant thumb caught the sharp edge of an unused screw hole. Remove the largest M.2 heat shield from the motherboard first, as it covers the hole for the central mounting peg. Lower the board in, making sure all the holes line up with the standoffs and the rear I/O, before screwing it down with the circular screws. Once secured, replace the M.2 shield.

2 PROCESSOR PRIMED

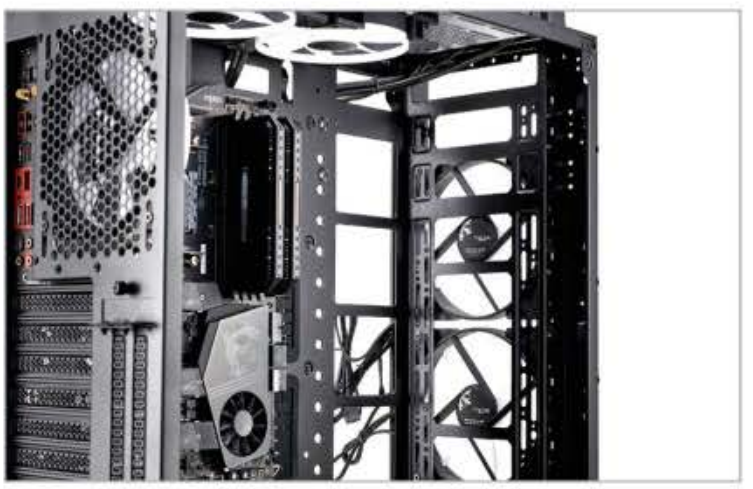
GRAB YOUR MOTHERBOARD and put it on top of its box, or on your workbench. Don't let the board touch the outside of the antistatic bag it comes in—only the interior of the bag dispels static, the exterior can have the opposite effect. Install the CPU by lifting the metal retention arm, carefully dropping the chip into the socket, and lowering the arm to lock it into place. Remember to align the little gold triangle on the corner of the chip with the triangle on the bracket. Next up is memory; there's a little printed direction on the board highlighting which two DIMM slots you should be using, in this case A2 and B2, the second and fourth slots away from the CPU socket. Simply open the clasps at either end and slot the RAM into place, making sure that both clasps click shut.

3 DRIVE DILEMMA

IT'S TIME TO DEAL WITH our drives. First up is the HDD. Remove the two screws from one side of the drive tray (it doesn't matter which side) and release the plastic clasp beneath. That lets you slide one side out to widen the tray, at which point you can insert the drive, making sure to align the holes on the side of the drive with the two blunt screwheads. Then reset the plastic clasp and return the two screws you removed, screwing them in to secure the drive, then return the tray to the cage. Next: the M.2 SSD. Remove the heatsink from the MP600 drive by unclipping it on each side and extracting the drive. Unscrew the mobo's heatsink and slot your drive into place, then remove the cover on the sticky heat pad, and push it down over the drive to screw it back into place.

5 FAN FOLLY

POP OFF THE TOP panel if you didn't earlier, then check the fan casings for arrows indicating airflow; the 140mm fans should draw air in, and the 120mm fans should expel it from the case. We started with the rear fan first, using one of the 120mm Prismas, holding it in place, and affixing the screws from outside the case. Be sure not to overtighten them, as it can warp the aluminum frame of the case. Move on to the front, fitting the two 140mm fans so they are both clear of the PSU shroud. Lastly, install the two 120mm fans to the case ceiling. Be sure to feed through the cables from all the fans, installing them so the cables are closest to the hole you're going to feed them through. Leave them bundled for now, though, or they'll get in your way during the PSU installation.



6 COOLING CRISIS

YOU'LL LIKELY WANT the MA610P's manual here. You need to use the AMD side of the backplate, fitting the square-headed screws and locking them in place with plastic caps. Make sure the backplate fits through the four holes around the CPU socket, then push it through from beneath, and screw on the standoffs. Next, attach the AMD brackets to the base of the heatsink tower, then remove the two fans, before screwing it down over the CPU with a small glob of thermal paste between the chip and the copper plate. Plug the fans back in and snap them on to the heatsink, then connect their power cables to the mobo on the CPU fan and pump headers. Check the fans are the right way around, to feed air toward the back. Feed the RGB cable through to the back of the case.

7 GRAPHICAL GOODNESS

NOW WE'VE GOT a nice easy step: GPU installation. Remove two of the blanking plates covering the rear I/O, setting the screws aside for later (we recommend keeping the plates in the GPU box), then make sure the clasp on the PCIe slot is open, and push the GPU down into it until it locks in place. With the card in position, take the two screws and return them to their original position to secure the GPU. There's not much else to be done here, so pour yourself a nice refreshing drink, and take a short break to slap a Band-Aid on your thumb. Speaking of thumbs, we advise you to keep your digits well clear of the reflective central plate on this 2070 Super, because it's a positive magnet for grubby fingerprints that'll ruin the glorious pure aesthetic of the card.

8 PSU POSITIONING

NEARLY DONE. Unscrew the rectangular plate from the rear of the case and unpack your PSU, keeping the power block and cables separate for now. Use four of the screws included with the case to affix the plate to the power block, then sort through your cables. You need five: a 24-pin ATX mobo power cable, a split-end GPU cable (this should have two split eight-pin connectors on one end), a SATA cable for the hard drive, and two eight-pin CPU power cables. The system will run fine with just a single eight-pin cable, but the second one adds power for overclocking. Feed the cables through the hole in the rear of the case, then slide the PSU into place, and secure it with the thumbscrews on either side. Take this opportunity to plug in the SATA cable for the HDD, too.

9 CABLE CAPERS

ON TO THE POWER CABLES. Untie the front I/O cables, as they can get in the way of threading cables into the main case cavity. Do them in size order, starting with the large ATX mobo power cable. Fitting the CPU power cables can be a squeeze up in the top corner of the case, so listen for the click of the connectors locking into place. The accessory cable is likely to have a lot of slack, so bundle it with any other excess cable lengths, between the PSU and the drive cage. Now move on to the front I/O cables, tucking any slack back into the Velcro strips in the case. The tiny power and LED cables are the trickiest. Find the closest hole in the frame to each connector, then thread through your cables, and secure them to the rear of the motherboard plate with cable ties or Velcro strips.

10 FAN FITTING

UNTIE THE BUNDLED fan cables. Feed through and plug in the power cables to the four-pin connectors closest to each one, then separate the RGB cables and daisy-chain them to each other. Each cable has a male and female connector, so you should have one of each type of connector left. Leave the male one unconnected, and plug the female one into the three-pin RGB connector on the mobo. Double-check that the cooler fans are connected to the same RGB cable via the two tiny connectors that run through the heatsink, then plug the RGB cable on to the four-pin header on the mobo. Secure any remaining slack cables, and return all the panels to the case.

1 **The case airflow is excellent, with air being expelled from the rear and upper side vents.**

2 **Corsair's iCue software can be used to customize the 24 addressable LEDs we've got in our memory.**

3 **The construction quality of the A500 TG case is unquestionable, but it's seriously heavy; a lot of work to carry about.**

BIG, BLUE, AND BEAUTIFUL

LOOKING AT THE NUMBERS, we're pleased with how this turned out. Roughly 20 percent performance improvement over our zero-point 1440p system is in line with the theoretical improvement of the 2070 Super over the GTX 1080 that system uses, and broader graphical performance in Fire Strike Extreme is great, too. The eight cores of the Ryzen 7 3800X work hard, hitting a good score in Cinebench R15 with no overclocking.

There's room for overclocking in both the CPU and GPU. The 3800X can hit as high as 4.5GHz with a manual overclock, potentially higher on individual cores with Ryzen Master's auto-overclocking mode—although you're constrained by the silicon lottery to a degree; the highest manual clock we reached was 4.3GHz. Cooling is well handled by this case, with great airflow that kept idle temps very low. The GPU and memory idle at 28 C, while the CPU varies from 30 C to 45 C.

At maximum stress, the CPU peaked at 68 C, proving that air cooling is very much a viable option. Running graphical benchmarks didn't see the GPU temperatures rise above 60 C, either. This system should be able to play just about any game on 1440p ultra settings, with ray tracing as a definite option as well, provided you're willing to drop your settings a tad to keep the frame rates steady. GPU overclocking makes 4K ultra a distinct possibility in some games, too.

Were we to build this rig again, we'd make a few tweaks. You might be wondering why we removed all the case fans when there's room for at least one or two to stay—that's because the MEG X570 Unify only has seven fan headers, and our build has seven fans. Seven independently powered fans, anyway; if you include the GPU and mobo fans, this is a 10-fan machine. It's surprisingly quiet, though, as the Fractal Design case fans are designed for minimum noise.

A fan controller might have been a good addition, allowing for a couple of extra fans in the front and roof, while adding hardware RGB control. We didn't use the small physical RGB controller included with the MA610P cooler, because it wouldn't have been properly compatible with the fans. A PWM fan hub would improve control; using the pump header for a fan means the fan curves have to be manually tweaked in the BIOS.

Talking of which, remember to engage A-XMP in the BIOS. Running the memory at full speed is important when using an AMD processor; while some programs only see very minor improvements, Cinebench R15 saw a 9 percent rise in performance when A-XMP was turned on. There's also Game Boost, which cuts your core use in half, but drew a few extra frames out of each game on our list (the figures in the table are using A-XMP only). Using Game Boost increases fan noise, though, so experiment with it.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread (Index)	959	2,144 (124%)
CrystalDisk QD32 Sequential Read (MB/s)	3,442	4,971 (44%)
CrystalDisk QD32 Sequential Write (MB/s)	1,706	4,252 (149%)
Rise of the Tomb Raider (fps)	95	107 (13%)
Total War: Warhammer II (fps)	55	70 (27%)
Tom Clancy's Ghost Recon Wildlands (fps)	48	58 (21%)
3DMark: Fire Strike Extreme	9,126	11,813 (29%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an Intel Core i5-8400, 16GB (2x 8GB) of Corsair Vengeance LPX @ 2,666MT/s, an MSI GeForce GTX 1080 Armor, and a 500GB Samsung 960 Evo M.2 PCIe SSD. All tests were performed at 1440p at the highest graphical profile.

PROTECT YOUR DATA

Encrypt files, folders, and even entire drives to keep your data secure

WORRIED ABOUT THE SECURITY and visibility of your data? Do you have sensitive files you want to keep away from potentially prying eyes? Worried that your cloud backup isn't as secure as it might be? Concerned that the data on your laptop might be vulnerable to theft? Want to dispose of files—or an entire PC—without compromising the data (including previously deleted files) on it? You've come to the right place.

In this feature, we explore numerous options for protecting your data, both data stored on your PC and that backed up elsewhere, whether on local storage or in the cloud. We also reveal how to ensure all data you delete is shredded beyond recovery, too, enabling you to pass on a PC or drive to a new home without having to worry about the data previously stored on it.

When it comes to sensitive files, the solution lies in a process called encryption. File encryption works using cryptography to scramble the contents of files so they're unreadable without the correct authentication—usually a password that is used to unlock an encryption key, which in turn decrypts the file so it's readable. Some encryption can be further strengthened by the requirement of additional forms of authentication such as so-called key files or physical devices, like smart cards.

Encryption keys are created using special algorithms. Common examples include Advanced Encryption Standard (AES) and Twofish. The higher the bitrate, the more secure the key, so 256-bit is better than 128-bit, and 512-bit is better than 256-bit. Encryption is a resource-heavy process, particularly as bitrates increase, so be prepared to see protected files take longer to open or save. If you have a modern CPU, you'll find AES is by far the quickest encryption standard, thanks to the implementation of hardware-accelerated AES encryption on supported processors.

Encryption can be performed on individual files or entire drives, and that's where we begin our feature, with a comprehensive guide to scrambling the files on your PC. Turn the page to get started.

BY NICK PEERS

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WHEN IT COMES to encrypting individual files or entire drives, there are numerous options available. If you're running the Pro, Enterprise, or Education version of Windows, you'll find built-in options exist in the form of BitLocker and EFS—the box opposite reveals how BitLocker works and what you need to run it. EFS—Encrypting File System—enables you to individually encrypt files or folders using your Windows password as the encryption key. If the drive is stolen, the files are unreadable without your Windows account password.

To encrypt one or more files or folders, select them in File Explorer, right-click the selection, and choose "Properties." Click "Advanced" and check "Encrypt contents to secure data." Click "OK" then "Apply"—you're prompted to encrypt the parent folder if applicable for greater security. Make your choice, then click "OK."

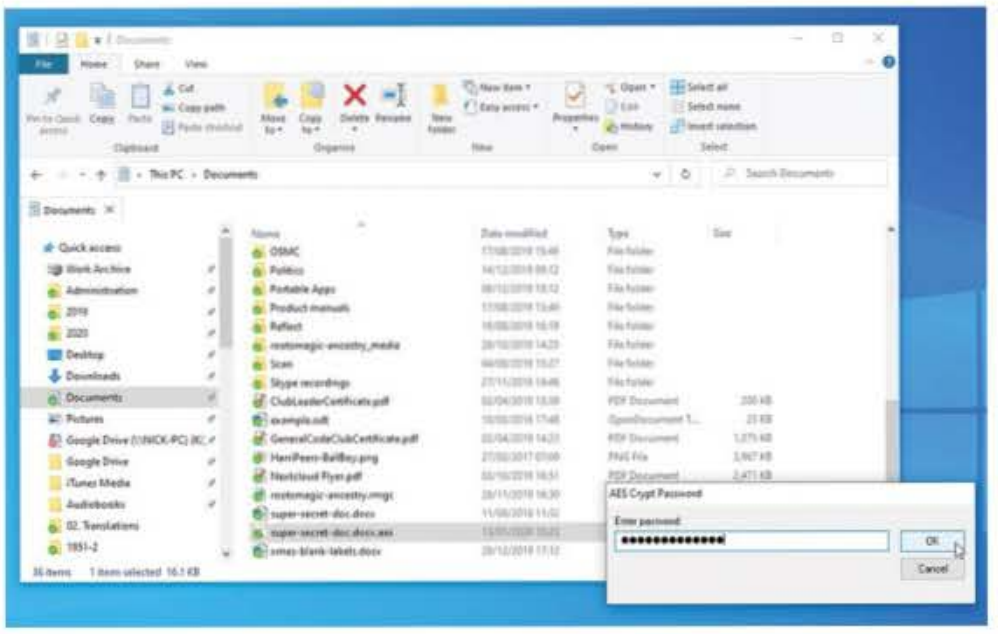
EFS is a simple but relatively weak way to encrypt files. If you're looking for something stronger, or don't trust Microsoft with keeping your data secure, read on.

Simple, fast file encryption

If you only need to encrypt individual files on a semi-regular basis—or wish to encrypt files before sharing them with others—the open-source tool AES Crypt (www.aescrypt.com) is all you need. Download and install the program, then going forward, simply right-click the file you wish to protect, and choose "AES Encrypt." Enter a strong password—the more characters, the stronger the encryption—and click "OK." An encrypted copy of the file with an .aes file extension is created, unreadable to anyone who doesn't know the password.

If you want to share the file with others, send them the encrypted version, then communicate the password separately and securely. They need to install AES Crypt before double-clicking the file and entering the password required to extract the decrypted original.

AES Crypt won't delete your original file after creating an encrypted copy.



It's also possible to encrypt Office documents—but encryption is only effective in Word 2007 or later when first AES 128-bit encryption and more recently (from Office 2016) AES 256-bit encryption is employed. To do so in Office 2007 or later, select the "File" tab and choose "Info → Protect Document → Encrypt with Password."

If you want stronger encryption for individual files or folders, Gpg4win (www.gpg4win.org) works in a similar fashion to AES Crypt, with the added bonus of allowing you to encrypt files using public keys protected by passphrases for additional security. After installation, launch the Kleopatra tool and choose "File → New Key Pair," then select "Create a personal OpenPGP key pair" to get started. Once done, you can then encrypt files by right-clicking them in File Explorer and choosing "Sign and encrypt'" to use your key (you can also encrypt files with a simple password, too, if you prefer).

A one-stop solution

AES Crypt and Gpg4win are perfect for occasional encryption, but you'll need to re-encrypt your files each time you make changes to them. If you want a more comprehensive, flexible solution, VeraCrypt (www.veracrypt.fr/en/) pretty much does it all. It can be used in a variety of ways to meet most people's needs—like BitLocker, you can encrypt entire drives, including your Windows boot drive, but you can also restrict its use to a specific set of sensitive files using a smaller virtual encrypted container, which resides as a file on your hard drive.

The app is available for Windows, Mac, and Linux, so you can use it across all your computers. There's a portable version available, too, which can do everything except encrypt your boot drive. After downloading and installing (or extracting to your portable apps folder), launch the program—Veracrypt-x64.exe if you're running the portable version—and you will find yourself at the main VeraCrypt window.

Create a virtual drive

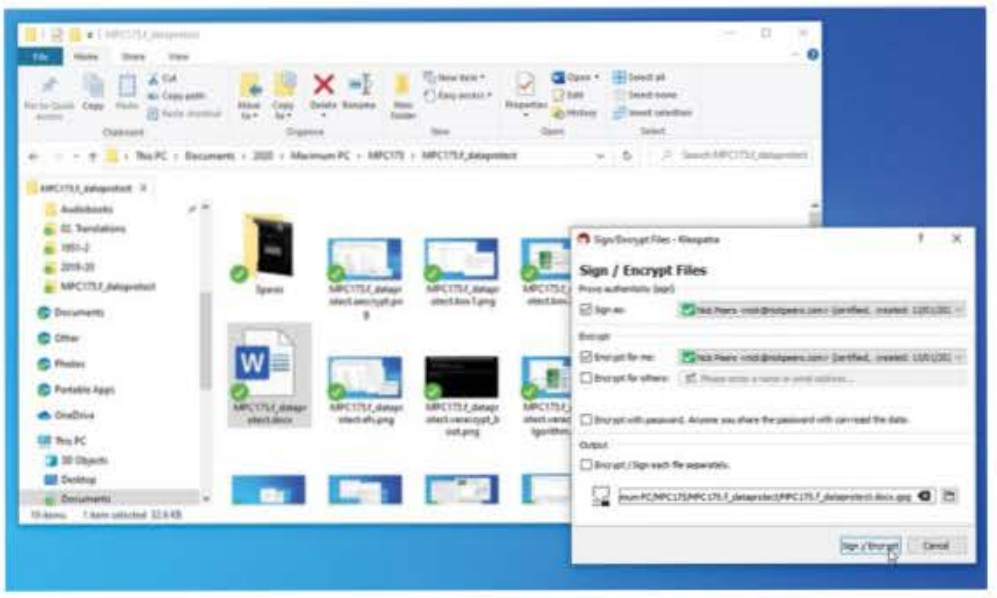
The VeraCrypt Volume Creation Wizard now opens, with "Create an encrypted file container" selected by default. This is the safest option, because it merely creates a single file on an existing hard drive, inside which all your sensitive data will be stored for you. There's no risk to any other files or drives. To proceed, click "Next."

Two types of volume can be created—to simply protect the data if the drive it's on is lost or stolen, leave "Standard TrueCrypt volume" selected, and click "Next" again. Skip to the next section. You'll also see an option to create a hidden volume, with an explanation about why you might want one. Hidden volumes are created inside standard TrueCrypt volumes, hiding themselves in their free space.

First-time users should select "Hidden TrueCrypt volume" then "Normal mode" to create a standard TrueCrypt volume inside which your hidden volume will be created. If

VeraCrypt's wizard makes it easy to create any kind of encrypted drive.

© MICROSOFT, AESCRYPT, VERACRYPT, CRYPTOMATOR



Encrypt individual files with a personal key using Gpg4win.

you've already created a standard volume, you can choose "Direct mode" instead when prompted, and follow the prompts to set it up inside your standard TrueCrypt volume. In either event, the wizard follows a similar process to that for standard volumes, as described below.

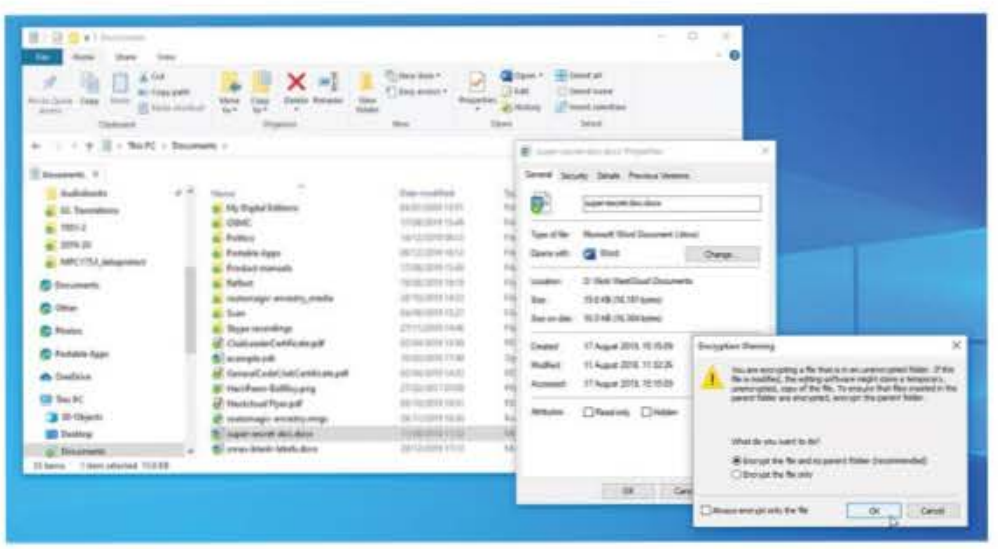
One tip if you plan to create a hidden volume: Be sure to save selected files to the standard volume. An empty standard volume would arouse suspicion among those you're trying to hide your data from.

Set up your standard volume

Click the "Select File..." button, browse to your USB thumb drive, then type a new file name into the "File name" box. Avoid using a file extension—this can be problematic—and click "Save." Click "Next" to choose your encryption options for the volume. Five encryption algorithms are supported: AES, Serpent, Twofish, Camellia, and Kuznyechik—select one at a time for a description. Beneath these are no fewer than 10 combinations of two or more algorithms for those who want multiple layers of encryption. The truly paranoid can click the "Test" button next to an option to verify VeraCrypt's implementation of the selected algorithm is compliant with certain standards.

Click the "Benchmark" button to open the Algorithms Benchmark window, then click "Benchmark" to compare the performance of each encryption algorithm. The process of encrypting and decrypting data will have an impact on disk write/read speeds, and you can compare the different algorithms (single and combined) from here. Straight AES encryption is recommended for most people, or AES combined with Twofish if you want a second layer.

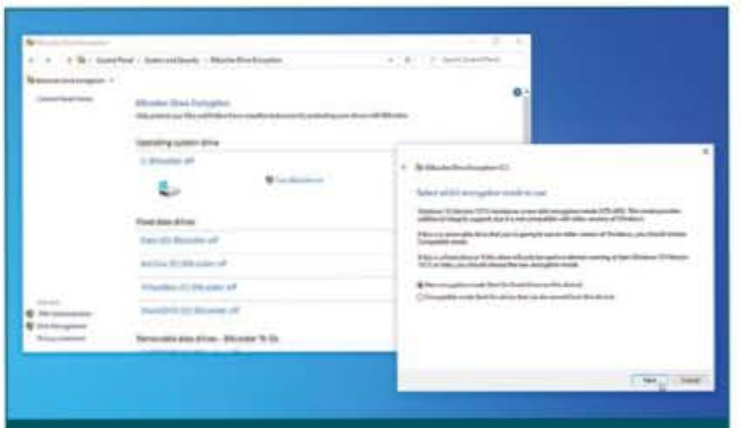
Beneath the encryption algorithm, you'll see a section on hash algorithms, complete with a handy link explaining how they work. These are basically used to generate the encryption keys and salt (random data used to protect your password from hackers). Five hash algorithms are currently supported, but for most people, the default SHA-512 is fine—you might choose SHA-256 if performance is more important than security.



Windows 10 Home users don't get access to native encryption tools.

Password & extra authentication

Once you've chosen your options, click "Next." You're now prompted to set a size for your file container. Choose a figure based on how much data you need to encrypt and how much free space is available. Click "Next" to enter a password—you'll need this to access your files in future, so make sure it's memorable (or stored somewhere secure, like your self-hosted Bitwarden



BITLOCKER DRIVE ENCRYPTION

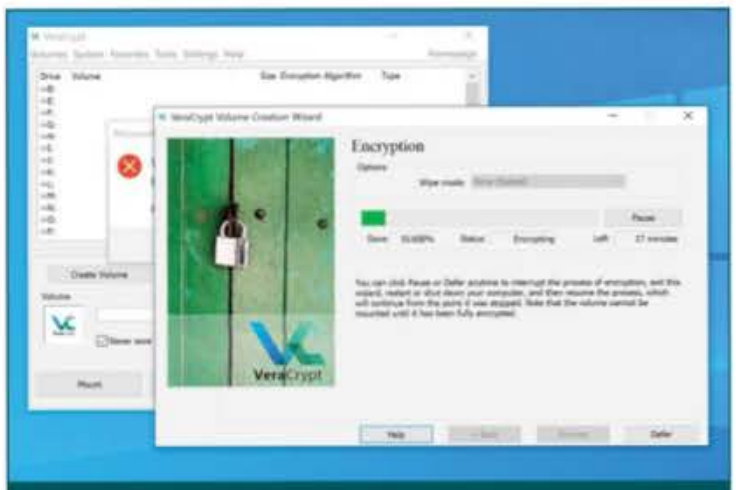
If you're using a higher-end version of Windows—Professional, Education, or Enterprise—and you're looking to encrypt an entire drive, you might like to use the built-in BitLocker tool. It can be used to encrypt fixed and removable drives, as well as your Windows boot drive, making it possible to protect the contents of your laptop should it be stolen.

Type "bitlocker" into the Search box and click "Manage BitLocker." You'll see a list of all available drives in the main window. Expand one and click "Turn BitLocker on." If you're looking to encrypt the main system drive, you may see an error about your PC not having a compatible Trusted Protection Module. Check your motherboard specifications—you may be lucky and simply need to enable TPM support in the BIOS (look in the "Security" section).

You're prompted to create a backup of the recovery key required, then follow the wizard, selecting appropriate choices depending on your drive and PC setup. Run the recommended BitLocker system check, and you should be able to use your drive while it's being encrypted.

Fixed or removable data drives are protected by password or a compatible smart card—TPM module not required. When you plug in the drive or reboot Windows, you need to provide the password or plug in the smart card to unlock the drive.

BitLocker is relatively straightforward to use, but relies on your trusting Microsoft, because unlike the open-source VeraCrypt, its code isn't available for audit. You're also restricted to its 128-bit or 256-bit AES encryption.

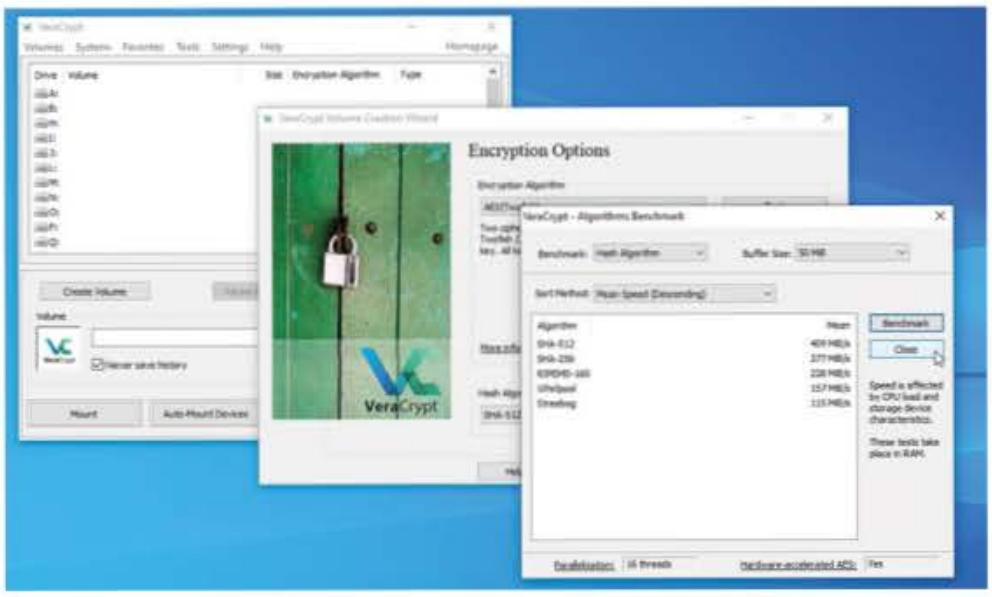


ENCRYPT IN PLACE

It's possible to encrypt an existing data drive without wiping it in VeraCrypt using "Encrypt in place." But there are drawbacks. Unlike encrypting your Windows installation, the drive won't be available while it's being encrypted. Also, when done, you're prompted to assign it a different drive letter—this isn't necessary as we'll explain shortly.

Choose "Encrypt in place," click "Next," read the warning, and click "Yes." You're prompted to set encryption and authentication options, then asked to move your mouse randomly to strengthen the encryption keys, before ending up at the "Wipe Screen." This allows you to shred unencrypted files after the drive has been encrypted to prevent them from being recovered by undelete tools later. Only the most paranoid should consider anything other than "None (fastest)" or "1-pass (random data)."

Click "Next," then "Encrypt." Click "Yes" (you may need to click "Yes" again if the drive is in use, to dismount it), then wait for the drive to be encrypted. Once done, read any warnings, and click "Finish." To keep the same drive letter, right-click "This PC" in File Explorer, and choose "Manage." Identify your encrypted partition using its drive letter, right-click it, choose "Change Drive Letter and Paths," select the current drive letter, and click "Remove," then "OK." You should now be able to select the drive letter in the main VeraCrypt window, and click "Auto-Mount Devices" to follow the advice in the main feature to access the drive. If you wish to decrypt the drive permanently, select it, and choose "Volumes → Permanently Decrypt."



VeraCrypt's benchmark tool shows you how each algorithm or hash performs.

password manager), but also tough to crack. Try to make it at least 20 characters in length.

Gain additional protection by checking "Use keyfiles" and clicking the "Keyfiles" button. This adds another layer of protection: Not only do you have to enter your password correctly, but you also need to select whichever file (or files) you choose to be linked to your container. These files can be already present on your hard drive—choose a compressed format such as MP3 or Zip—or you can have VeraCrypt generate a new random key file from scratch. Either way, make sure the files are backed up somewhere safe, because if they're deleted or the first 1,024KB of data is changed, your vault will be impossible to access.

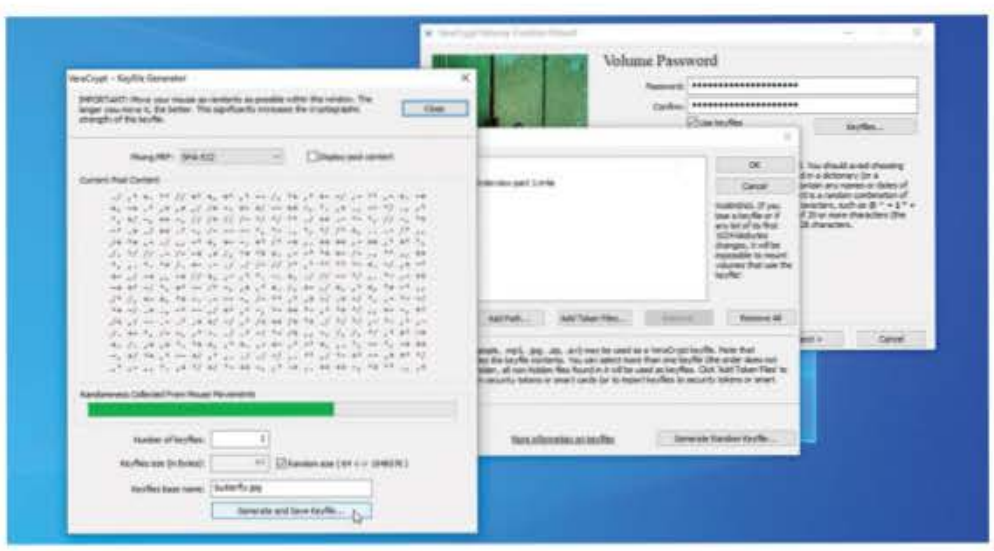
Checking the "Use PIM" box creates an additional step after clicking "Next," where you can set a custom Personal Iterations Multiplier. The default setting (485) prioritizes security over speed when mounting the volume after each system boot—should you wish to reduce the time taken, you can set a lower value, but make sure you've set a lengthy password.

Format & mount encrypted volume

After clicking "Next," you're asked if you plan to store files larger than 4GB in your new virtual drive—this determines which filesystem is set as the default in the next step (exFAT if yes, FAT if no). Click "Next" and you're ready to configure and format your volume. You can change the filesystem here—NTFS and ReFS are also available—plus choose whether to perform a quick format (not recommended). Checking "Dynamic" means the file containing your encrypted volume isn't formatted as its actual size, but instead increases in size as you add content to it—this comes with several warnings, not least of which are severely degraded performance and reduced security.

You'll see a prompt to move your mouse within the VeraCrypt window to improve the cryptographic strength of the volume's encryption keys. When you've configured the drive and the "Randomness Collected From Mouse Movements" meter is full, click "Format," and the encrypted volume is created. Wait until the confirmation dialog box appears, then click "OK" followed by "Exit" to return to the main VeraCrypt window, ready to access your encrypted container for the first time.

Select a free drive letter from the list and click the "Select File" button to choose your encrypted container. Click the "Mount" button and then enter the volume's password before—if applicable—clicking the "Keyfiles..." button to select the required files that will give you



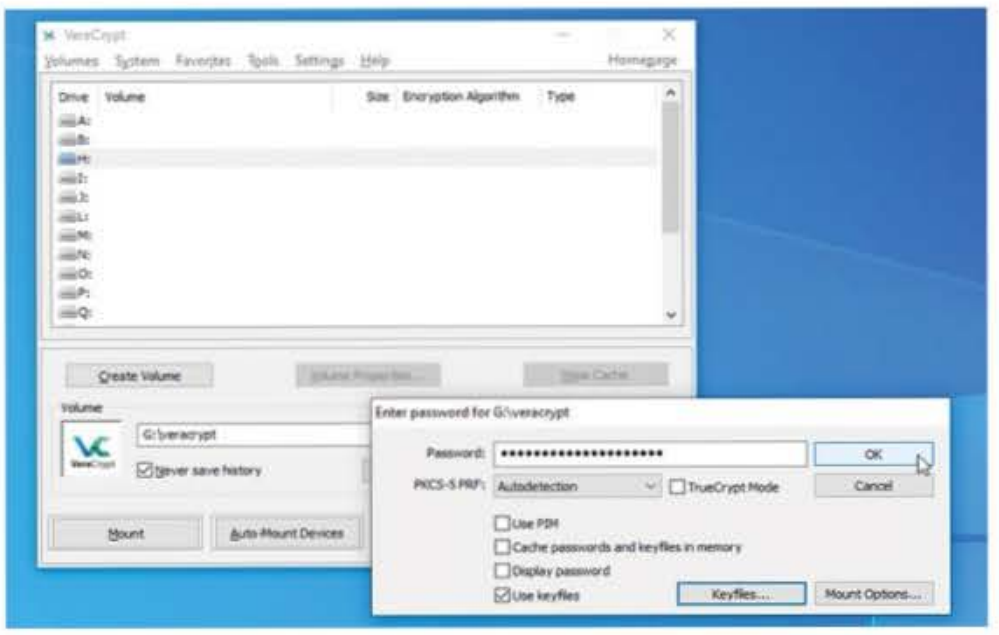
Key files add an additional layer of security to your encrypted data drives.

access to your container when you click "OK."

You'll see a "Mount Options..." button; clicking this reveals options such as opening the volume in read-only fashion, or assigning it a specific drive label in Windows. If your volume contains a further hidden volume, be sure to check "Protect hidden volume against damage caused by writing to outer volume" to safeguard its contents.

After clicking "OK," wait while the volume is mounted—you should see your encrypted container appear in the main VeraCrypt window. It can now be accessed like any other drive—copy or save files directly into here to ensure they're protected going forward. When you've finished with the drive, right-click its entry in the VeraCrypt window, and choose "Dismount" to lock it away from prying eyes.

After setting up, mount your encrypted drives for access.



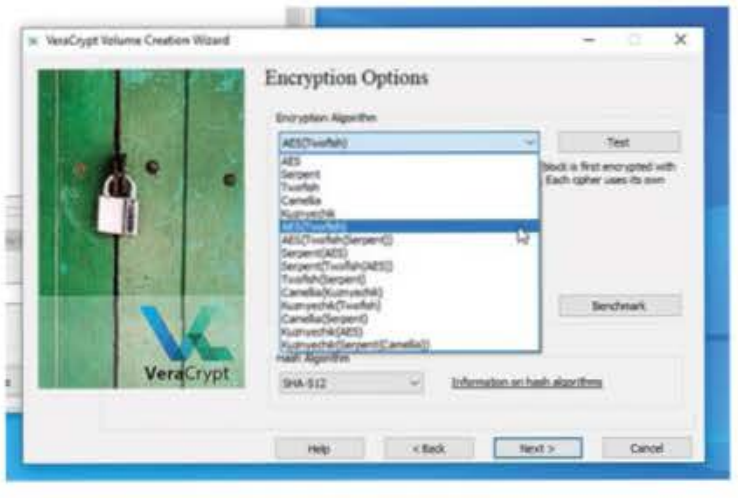
Encrypt your Windows installation

VeraCrypt can also be used to encrypt your entire Windows installation. All files remain encrypted on your disk even in use—they're simply decrypted on demand to allow Windows and your apps to run normally without exposing the data to potential problems, such as sudden power loss.

This form of encryption is particularly suited for those who carry sensitive information with them—typically on a laptop. Take a drive image backup before you begin, then launch VeraCrypt and choose "Create Volume → Encrypt the system partition or entire system drive." Again, standard and hidden options are available (click "More information" if you like the idea of hiding your OS from view—it's a long, detailed subject, and involves creating a "decoy" OS).

Assuming you simply want to encrypt the drive, leave "Normal" selected and click "Next." You can opt to simply encrypt the Windows partition, or the entire drive (so all partitions on the primary hard drive). If in doubt, encrypt the system partition only—you may get a warning when attempting to encrypt the entire drive about losing access if it has a so-called "inappropriately designed" BIOS.

You need to balance security versus performance when picking an algorithm.



The next step informs VeraCrypt whether you have a single-boot or multiboot system, and then it's a similar process as for creating an encrypted virtual drive. One caveat: You can only protect your system drive with a strong password; key files aren't supported. You also need to create rescue media—don't skip this step, because it's required to both permanently decrypt your drive and provide protection against corruption.

Different media is required depending on whether your boot mode is EFI (USB flash drive) or MBR (CD/DVD)—just follow the prompts to create and verify the media. The recovery media is tied to your specific PC and the current password you've assigned to your boot drive. If you make any hardware changes, you need to recreate it.

You next see the "Wipe Mode" screen, which enables you to securely overwrite the unencrypted copies of your files after they've been encrypted—the more passes, the slower the process, so unless you have reason to be truly paranoid, none or just "1-pass" should be sufficient.

Test and encrypt

You're now ready for the drive to be encrypted—first, a pretest is run to verify everything works as it should do. Your PC reboots, and you're prompted to enter the password you just set up. When prompted for the PIM, just press Enter unless you manually specified this value. Wait for the password to be verified—then Windows boots as normal.

If the test passes, click the "Encrypt" button and VeraCrypt starts to encrypt your drive's contents (a "Defer" button is also present if you wish to back up data first—you're then prompted again the next time Windows is restarted). Unlike with encrypting non-system volumes, you can carry on using your PC while the drive is encrypted.

Once complete, your computer's contents are protected against theft and other threats, ensuring any data stored on the drive is secure.

Encrypt entire drives

VeraCrypt can also be used to encrypt other drives and partitions, from internal data drives to USB thumb drives. As with all major operations, we strongly recommend you first take a full image of your hard drive before starting the process—just in case. Once the drive is safely encrypted, you can safely delete this backup. However, if you plan to keep the backup, check out the box on page 41 about encrypting backups.

The creation process is similar to setting up virtual drives. Start by selecting "Encrypt a non-system partition/drive" on the first page of the wizard. Choose whether the volume will be a standard one or hidden, then click "Next." Click "Select Device..." to choose your target drive or partition.

The next step is crucial—you have a choice between "Create

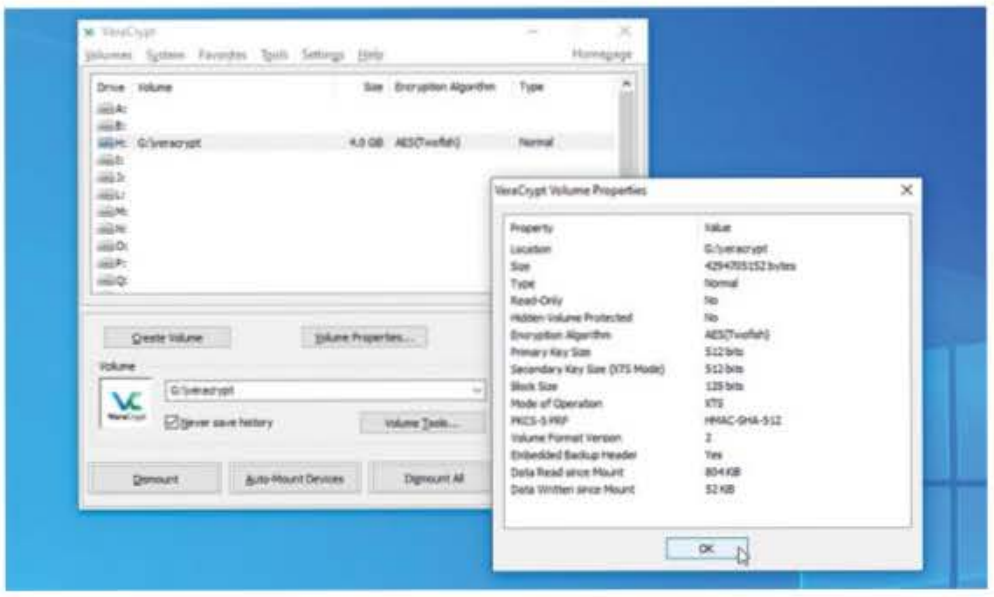
SHRED DATA SECURELY

When you delete a file, it's not physically removed from your PC; instead, the first few bytes of the file are overwritten with a tag that tells Windows that the file is deleted and the space it currently resides in is available when writing other files to disk. It speeds things up, but it's not good for security.

Until the file is physically overwritten by another file, its contents are still retrievable. What's more, even if the file is overwritten, it might be possible to retrieve part or all of it using sophisticated file recovery techniques. So, how do you protect yourself against that kind of technology?

Thankfully, there are tools that can securely wipe data from your drive. One that's free and open source is Eraser (grab the latest stable version, 5.8.8, from https://eraser.heidi.ie/download). During installation, enable the Windows Explorer extension to allow you to securely shred any file by right-clicking it and choosing "Eraser → Erase." What about files you've previously deleted? Eraser can securely wipe all free space to make deleted files unrecoverable—right-click the drive in File Explorer, and click "Erase → Erasing Free Space."

Open the main Eraser program and you can set up on-demand and scheduled tasks to periodically shred specific files, files in folders, or free space. By default, Eraser wipes data using the Gutmann technique—if this is too slow, choose "Edit → Preferences → Erasing" to choose a different method, including one of two used by the Department of Defense.



Select "Volume Properties..." to verify the security of your drive.

encrypted volume and format it" (destructive, and best for empty drives or drives with no data worth keeping) and "Encrypt partition in place." The latter is much slower but preserves existing data—see the box on page 38 for details. If creating an encrypted volume from scratch, the process is virtually identical to creating virtual drives.

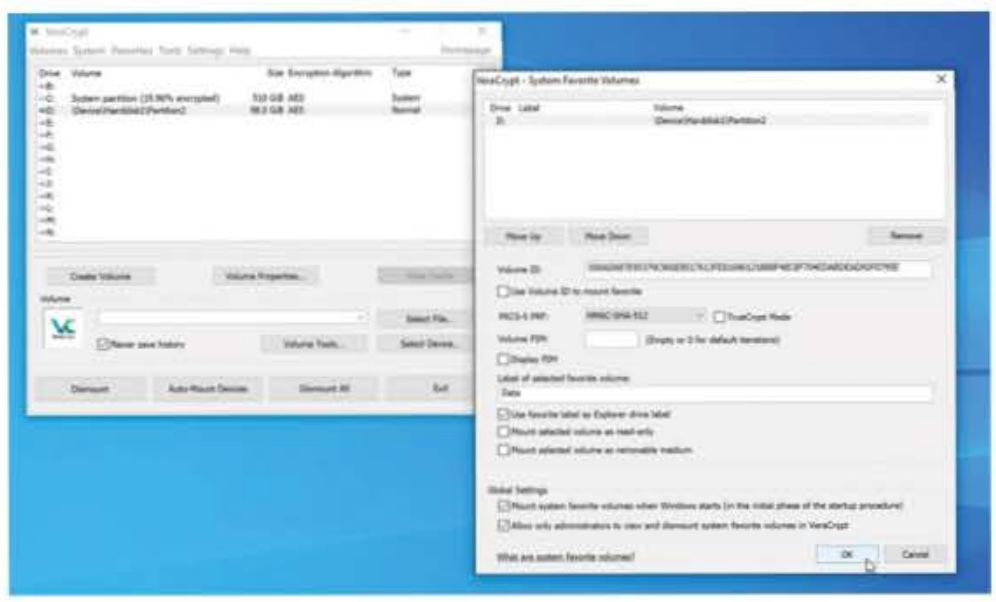
Once the drive has been encrypted, read any warning messages, then click "Finish." To mount the drive, select the drive letter you wish to assign to it, then click "Auto-mount Devices." Enter the credentials required, wait, and then the drive is mounted and available. Ordinarily, you have to do this every time you restart Windows—to have the drive automatically mount when you log into Windows, right-click it in the main VeraCrypt window after mounting, and choose "Add to Favorites." Be sure to check "Mount selected volume upon logon" before clicking "OK." Going forward, you are prompted to provide the password and any key files each time you log into Windows, and then the drive is available.

One problem with this approach occurs if you've moved system folders—such as user folders or those linked to cloud services—on to this encrypted storage space. You get errors about missing folders before you unlock the drive. If you've encrypted your Windows boot drive, you can get around this by ensuring the password on your data drive is the same as that required to unlock your Windows boot drive, then choose "Add to System Favorites"—this way, the drive is unlocked with your boot drive, and available when Windows loads.

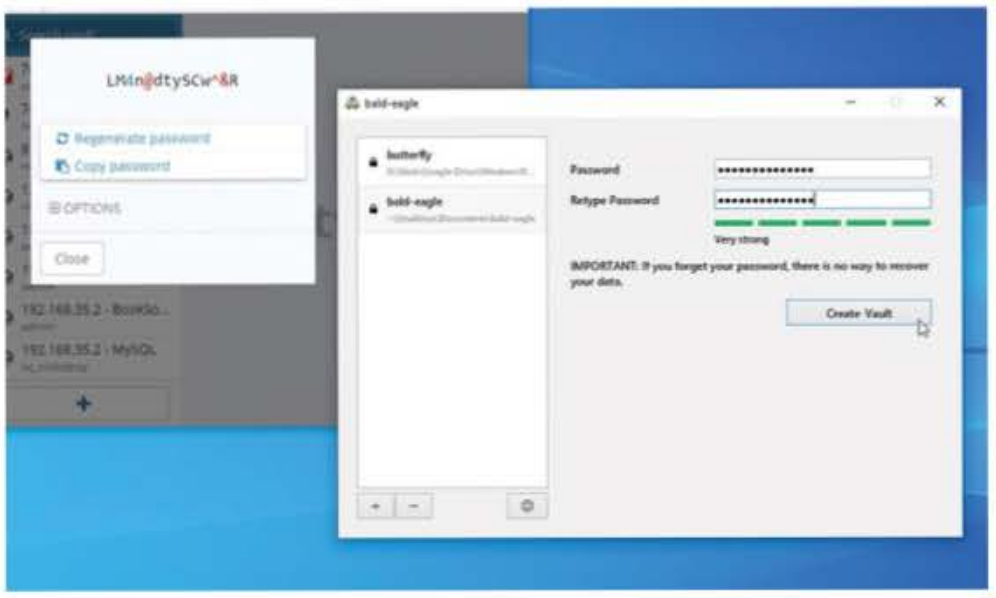
Encrypt cloud backups

VeraCrypt can protect your files locally, but copy them anywhere else, and they're left unprotected. The box opposite reveals what to do about protecting local backups using the same types of algorithms with suitable backup software, but what about those files you back up to the cloud? Cloud providers claim to encrypt your files, but sometimes that only applies to the way the files are transferred—when stored "at rest" in the cloud, they may be left unencrypted, and therefore potentially vulnerable.

Even where encryption is provided, is it true end-to-end encryption, where only you possess the all-important encryption keys required to decrypt the files? Some cloud providers—SpiderOak (https://spideroak.com) and Tresorit (https://tresorit.com),



Mount encrypted data drives automatically with Windows.



Strengthen your Cryptomator vault by using a randomly generated password.

for example—adopt this "no knowledge" policy, but others don't.

You don't need to switch cloud provider to get this kind of protection; instead, add your own layer of encryption to critical files, with keys not shared with anyone else. An open-source encryption tool designed for cloud-based storage is Cryptomator (https://cryptomator.org), which works with any cloud provider from OneDrive to Dropbox. The principle is identical to VeraCrypt: You create a password-protected virtual drive—or vault—inside which your sensitive files are stored. The key difference is that Cryptomator encrypts files and folders individually, rather than as part of a larger file, so changes are smaller and quicker to upload and download.

Create a Cryptomator container

To start, go to www.cryptomator.org/downloads and click "Download 64 Bit." Once saved to your hard drive, double-click the setup file, and follow the install prompts, making sure you install the "Dokan File System Driver" when asked. Reboot if prompted.

Open Cryptomator via the Search box or Start menu, then enable the integrated update check when prompted to ensure Cryptomator stays up to date. Click the "+" button and choose '"Create New Vault." Navigate to your cloud folder, give your vault a suitable name (this will be the name of the folder containing your encrypted files on the drive, so don't make it too obvious), and click "Save."

You're prompted to create a password to protect the vault and access it from other computers or mobile devices. We recommend generating a long random one using your password manager (store the password as a secure note). Once entered and safely recorded, click "Create Vault."

Click "More Options" to save the password and automatically mount the drive at startup (only recommended on a secure PC). You can also change the drive name and choose a drive letter. Then enter your password and click "Unlock Vault."

A new Explorer window eventually opens, pointing to your new virtual drive (it's also accessible via "This PC" under "Network locations")—simply copy or save files in here, and they're encrypted securely before being uploaded to the cloud.

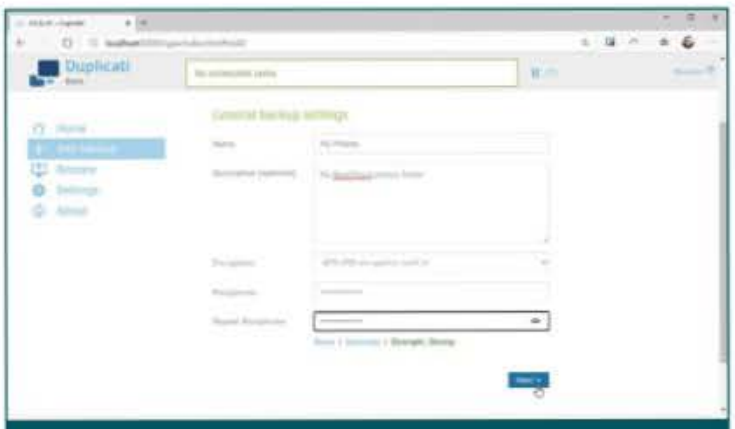
When done, you can leave the drive unlocked until you shut down your PC or—if security is an issue—open the main window and click "Lock Vault" to close it down (enter your password and click "Unlock Vault" to bring it back later if you need to).

You can access your cloud-hosted vault from other computers by installing Cryptomator on there and choosing "Open existing vault." There are even paid-for apps for Android or Apple phones if you need to upload sensitive files while on the road.

Shortcomings

Our main gripe with Cryptomator is that its presence can't be hidden—and, in fact, is blindingly obvious to any hacker combing through your folders. That's because its master key is visible inside the folder containing your encrypted data (even the name—masterkey.cryptomator—isn't subtle). This highlights the need to keep an independent backup of any data stored in a Cryptomator vault in case these key files are damaged or lost.

If that's a deal-breaker, consider switching back to VeraCrypt, but minimize the size of your vault (make multiple smaller vaults, rather than one large one). This helps reduce the amount of bandwidth used when uploading and downloading changes to encrypted files. Another approach is to use cloud storage for encrypted file and image-based backups (see box above).



ENCRYPT BACKUPS IN THE CLOUD

You've encrypted the files on your hard drive, but what about your backups? By default, backup tools store your files unencrypted on a local or network drive, which is fine if the drives have been encrypted with VeraCrypt or BitLocker, but what if you just want the backups to be encrypted; perhaps you'd like to store them securely in the cloud?

The answer lies with the free and open-source backup tool Duplicati, currently in beta (www.duplicati.com). This has been engineered like Cryptomator for the cloud, but specializes in file-based backups. After downloading and installing, let Duplicati launch—configuration is done through a browser window. Click "Add backup" to work your way through the backup wizard. You're prompted to set your encryption level (the default AES-256 is more than adequate) and passphrase at the start.

Next, select your destination. You can back up locally or directly to a range of cloud providers—Google Drive, OneDrive (choose the v2 option), Dropbox, and so on). If yours isn't listed, choose your cloud provider's local folder, and let its native app sync the backup files after it's been taken.

From here, select which files and folders to upload, set a schedule for updating the backup, and choose how many backups to retain. Click "Save," then opt to run the backup now. A progress meter shows how far it's got—look at the throttle button if the uploading impacts your Internet performance.

When it comes to recovering files, select "Restore," and follow the wizard—you can recover individual files as well as older versions of a file.

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This Samsung C49HG90 uses quantum dot technology, enabling HDR thanks to a combination of QLEDs and a VA panel.

2020 VISION

What's hot and what's not in screen tech in 2020? *Jeremy Laird* takes a deep dive into the PC monitor market

SCREENS TODAY OFFER more innovation, wider choice, and better value than ever. But, by some metrics, PC displays are disappointing. By other measures, though, marketing madness is starting to take hold.

How so? On the one hand, you can now choose from a huge array of form factors, sizes, and aspect ratios, many of which are more affordable than ever. Innovations such as high refresh rates and adaptive sync have entered the mainstream. Support for HDR or high dynamic range content is becoming widespread, too. Connectivity solutions such as USB Type-C make it simpler than ever to hook up displays to PCs of all kinds. And panel tech is improving, with better contrast, lower response times, and technologies such as local dimming contributing to dramatic improvements in image quality.

On the other hand, some elements of screen tech refuse to move forward. The most obvious involves pixel density, an issue that's related to screen resolution. But outright screen resolution is also stuck, with few monitors breaching the 4K barrier.

Even where there has been progress, the benefits are not always clear cut. Significant confusion surrounds the implementation of HDR support in PC monitors, for instance. That's the polite way of describing a huge amount of HDR marketing FUD (fear, uncertainty, and doubt). Likewise, refresh rates continue to escalate despite diminishing returns. And the price of USB Type-C connectivity remains painfully high.

In hindsight, it's also disappointing that LCD technology remains dominant. Five years ago, you'd have put good money on OLED achieving at least some significant penetration into the PC monitor market. Save for some limited appearances in laptop PCs, it's virtually non-existent.

If that's a helicopter view of screen tech in 2020, it's time to swoop down into the detail.

4K remains state of the art in 2020.

HP's Z38c is a stunner, but it's not high DPI.

Will Apple's 6K panel turn up in a PC screen?

IF THERE'S A SINGLE metric by which PC display technology disappoints in 2020, it has to be pixel density. A decade ago, it seemed inevitable that high-DPI displays would be the norm on the PC by now. The reality? DPI levels on most displays barely breach 100. In other words, there has been little or no change from 10 years ago.

DPI refers to dots per inch, a measure of how densely pixels are packed into a given area of screen. The denser or more numerous the pixels, the sharper and clearer the image. Fonts are particularly sensitive to pixel density, but it's important for screen clarity and image detail, period.

Take the new HP Z38c, a desirable new 38-inch ultrawide monitor, with a $1,200 price tag. At first glance, the Z38c's native resolution of 3840x1600 pixels sounds like plenty to justify its premium positioning. But do the pixel density math, and the result is a DPI of just 109 pixels per inch. That's actually slightly worse than a bargain basement 1080p 20-inch monitor that you might pick up for $75.

Compared to smartphones, that kind of pixel density is pathetic. Even budget smartphones typically deliver upward of 300 dpi. Of course, smartphones and PC monitors are not directly comparable. The practical impact of pixel density in terms of image quality depends upon viewing distance. The shorter the viewing distance, the more pixels are required for a given level of detail or clarity.

Obviously, phone screens held in the hand are viewed at shorter distances than PC monitors. Apple's "Retina" display standard provides a useful metric. The idea behind it is the human eye's ability to resolve individual pixels. The point at which the pixels are so small they can't be individually discerned is the point at which adding further pixels does nothing to improve sharpness and detail. You can achieve the "Retina" point by moving a display further away or by adding pixels.

Apple puts that point at around 300 dpi for smartphones and 200 dpi for desktop and laptop displays. It's not an exact science and one can debate the distances, required DPI levels, and the acuity of the human eye. But Apple's approach provides a tolerable rule of thumb and a context in which a mere 109 dpi obviously isn't even close. That's an observation confirmed when you compare the quality of fonts on a display with a DPI of around 100 with another good for 200 dpi. The latter has much cleaner, sharper fonts.

PIXEL PORTENT

Consider the broader PC monitor market and you'll quickly find that vanishingly few products offer a true high-DPI experience. Take something like a 27-inch 4K monitor with fully 3840x2160 pixels. Impressive? Yes. But spread over that 27-inch diagonal, the result is 163 dpi. Not bad, but still well short of the Retina standard. Even a 24-inch 4K display only clocks in at 184 dpi.

What if you up the ante to 5K? LG's 5K2K monitor, the UltraWide 34WK95U, is a 34-incher and delivers 163 dpi. Speaking of LG, it also offers the 27MD5KA UltraFine, a 27-inch model with 5120x2880 pixels. Finally, we have a monitor that can top 200 dpi—the UltraFine is good for 218 dpi. Still, what that monitor shows is that you need a heck of a lot of pixels to achieve truly high DPI on larger displays.

Apple's new $6,000 32-inch Pro Display XDR, for instance, needs a 6K resolution of 6018x3384 to achieve the same 218 dpi as the LG UltraFine. And it's not really PC compatible. Another example is Dell's 8K monitor, the UP3218K. With 7680x4320 pixels and a 32-inch diagonal, it's good for 275 dpi. It's a proper high-DPI display, for sure, but it's very much the exception. And a $3,500 exception at that.

Speaking of exceptions, portable PCs are the cheapest and easiest way to get a high-DPI experience. Many notebook, tablet, and convertible PCs are at least optionally available with screen DPIs of 200 or more. But unless you prefer using a laptop screen, that's not much help.

Sadly, there is little near-term prospect of things improving. Actual LCD panels, as opposed to entire monitors, are only made by a very small number of companies. If said companies aren't offering large format high-DPI panels suitable for PC monitors, there's nothing display manufacturers can do about that. Among the big players in LCD manufacturing are LG, Samsung, and AU Optronics. As a rule, they're pretty open about their forward planning for upcoming LCD panels. For 2020, there's no sign of any new panels that will bring high DPI into the mainstream PC monitor market.

Indeed, our research couldn't uncover any new panels due out in 2020 with a resolution beyond 4K. As we've seen, you need more than 4K to achieve a high-DPI experience on larger monitors. We're not even sure if the new 6K panel in the Apple Pro Display XDR will be available for

IN SEARCH OF HDR

HDR, or high dynamic range, has always been a tricky concept, but in the recent context of PC displays, it's been more problematic than ever. What with numerous competing standards and no unifying definition of what it takes to be an HDR display, it's a minefield for buyers.

Arguably, the problem is even more fundamental than that. The ability to support or decode HDR content is one thing, the ability to render an HDR image is another. To the discredit of many monitor companies, they've conflated the two. But not all manufacturers are guilty.

By way of example, in our review of the new BenQ DesignVue PD3220U, we noted that BenQ says the display "supports HDR10 content." Arguably, BenQ could be even more explicit, but it's welcome that the company doesn't pitch the PD3220U as an HDR monitor. A quick perusal of its specs, for instance, reveals

Dell's 8K panel is one of a few high-DPI ones.

2020 won't be the year of OLED PC screens.

New LG IPS panels claim 1ms response times.

© LG ELECTRONICS, HP, APPLE, DELL

other monitors. The Pro Display's panel is believed to be manufactured by LG, but it might be an Apple exclusive—at least for a time.

All of which means that 2020 won't be the year 5K, 6K, or 8K becomes more accessible on the PC. Nor will it be the year that OLED makes the jump from TV to PC. It once seemed inevitable that OLED technology would eventually take over from LCD as the default technology for PC monitors, but here we are in 2020, and OLED availability in desktop PC monitors is virtually zero.

Again, the picture is a little better in the mobile market. A number of laptops, such as Razer's Blade 15, can be had with OLED screens. But it's increasingly looking as though OLED may never become dominant for desktop monitors. Instead, the PC monitor market may largely skip OLED and jump straight to microLED.

OLED suffers from a number of problems, including burn-in and asymmetric degradation, that are particularly problematic for the PC. In terms of the former, the persistent elements of the Windows interface, such as the taskbar, make burn-in much more likely. The longer the image on an OLED display remains static, the more likely that image is to be "burned in." The result, on a PC, would be a faint image of the taskbar permanently burned into the display.

DEGRADING EXPERIENCE

As for degradation, the first problem is that OLED light output degrades over time and with use. What's more, the individual subpixel diodes degrade at different rates. PC displays typically have pixels made of red, green, and blue subpixels. The blue diode subpixels in an OLED display degrade much faster than the red and green diodes. Without compensation, not only would your display become dimmer, but the color balance would shift as the blue diodes dimmed. Various technologies do exist to compensate for this, but PC monitors are generally more sensitive to color shifts and involve more persistent interface elements than TVs.

The alternative is microLED. For starters, it's brighter than OLED, but it's also more stable than OLED. It degrades more slowly and the rate of decay of the red, green, and blue subpixels is more even. MicroLED is also much more resistant to burn-in while simultaneously offering all the advantages of OLED, such

a maximum brightness of just 300cd/m². That's insufficient for true HDR visuals.

What is sufficient? HDR10 support just indicates signal processing capability. More useful and widely applied by many manufacturers is the VESA DisplayHDR standard, which actually encompasses multiple standards. The entry-level DisplayHDR 400 certification is not, in our view, true HDR. It involves a peak brightness of 400cd/m² and only sRGB color gamut support. All the other levels of DisplayHDR certification demand at least some local dimming, which is critical for HDR for enabling the much higher contrast involved in true HDR visuals, plus a wider color gamut, and better controlled black levels. But we think it's only with DisplayHDR 1000, a standard that requires a sustained brightness of 1,000cd/m², very low black levels, and local dimming, that you get a really rich HDR experience.

Of course, all of that applies to LCD monitors; OLED is a whole different ball game and has its own HDR standards. But as we explain elsewhere, OLED isn't about to become mainstream in PC monitors.

Is BenQ's DesignVue PD3220U really an HDR display?

© BENQ

GET CONNECTED IN 2020

Oft overlooked but ever important, the humble display interface is due an overhaul in 2020. One major development will be the roll-out of DisplayPort 2.0. It's a major upgrade versus the most recent prevailing DisplayPort standard, namely 1.4a.

DisplayPort 2.0 delivers a 3x jump in raw bandwidth compared to DisplayPort 1.4a. Want hard figures? 1.4a serves up 25.92Gb/s of usable bandwidth for transporting display images; DisplayPort 2.0 ups that to 77.37Gb/s.

As for the implications of the bandwidth bump, they're numerous. The more bandwidth, the higher the resolution you can display at greater refresh, and with more dynamic range and color fidelity. For example, with DisplayPort 2.0, you'll be able to drive dual 8K monitors at 120Hz and 10 bits of color per channel over a single interface. In terms of a single panel, a 16K monitor—15360x8640 pixels—at 60Hz will be possible. Or how about triple 10K panels at 60Hz? Another option supported by DisplayPort 2.0.

Long story short, all those high-res, high-DPI panels we're hoping for will finally be possible with DisplayPort 2.0. As for HDMI, its most advanced standard, 2.1, was announced in 2017, and no further advances have been made public. HDMI 2.1 actually compares favorably with DisplayPort 1.4a, with 42.6Gb/s of usable data. It's designed to cater for 8K resolutions with refresh rates up to 120Hz. So, it's pretty much got you covered.

Finally, there's USB Type C and Thunderbolt 3, sharing the same interface. This is a frustratingly complex subject, but the short version is that both support up to DisplayPort 1.4 in Alt Mode over the USB/Thunderbolt interface. Some examples are the Microsoft Surface Pro 7, Surface Pro X, and Surface Laptop 3, all of which support up to DisplayPort 1.4. Some even support multi-stream capability, so you can connect dual 4K 60Hz monitors via a single cable. But note: Most portable PCs made up to mid-2019 are likely to only support DisplayPort 1.2 in Alt Mode, and thus a single 4K 60Hz display.

as effectively perfect or infinite contrast and ultrawide viewing angles.

Sounds like the perfect solution for the PC, right? One day, it probably will be. For now, there are serious limitations. MicroLED is very expensive to manufacture. Current implementations are also very power-hungry. Time will tell whether OLED can solve its degradation issues before microLED gets cheaper and more efficient. Our hunch is that microLED will win out eventually.

If neither OLED nor microLED are going to be a thing anytime soon, how is display tech actually progressing in 2020? One of the most obvious elements involves refresh rates, be that the overall rate of refresh or synching that refresh with the output of the video card. High refresh beyond the industry standard of 60Hz and adaptive synching have been available for years, but the technologies are becoming more refined and more widely adopted.

One of the two competing standards in this area is AMD's FreeSync. It's been around for six years, and for 2020, AMD announced what is effectively its third major iteration. This includes two new tiers: FreeSync Premium and FreeSync Premium Pro. FreeSync Premium adds a requirement of at least 120Hz refresh support at a minimum 1080p resolution and low frame rate compensation to FreeSync's core adaptive sync capabilities. As for FreeSync Premium Pro, that adds accurate luminance and wide color gamut as part of a broader HDR certification.

Meanwhile, Nvidia's G-Sync technology has also developed into a similar multi-tier proposition, with G-Sync Ultimate topping the table with HDR requirements. Overall, there are two takeaways that apply to both. Firstly, for the most part, both are mainly of interest to gamers. High refresh is of general benefit for all kinds of computing, albeit with less impact outside of gaming, but other features, such as frame synching and ultra-low latency, really are only of interest to gamers.

The other issue to be aware of is compatibility. Previously, Nvidia was attempting to lock down G-Sync to its own video cards and displays fitted with G-Sync boards. But Nvidia has now unlocked support for FreeSync monitors with Nvidia graphics cards via the G-Sync Compatible standard. If you buy a G-Sync enabled PC monitor, though, note that you still need an Nvidia graphics card for full functionality.

DisplayPort 2.0 is a bandwidth bomb.

TRUTH HERTZ

Speaking of refresh rates, we fear 2020 will be the year that marketing madness takes hold. The first 360Hz gaming monitors have been announced (and on show at CES; check out page 15 for Jarred's thoughts). But the added benefit, even for esports addicts, of the jump from 240Hz to 360Hz is debatable at best. That would be true with a display technology fully capable of rendering 360 frames per second, but it is itself debatable whether the pixels in LCD panels respond quickly enough to make 360Hz meaningful.

That's before you ask whether you have a fast enough 3D card to play a given game at the 400fps or so average you'll realistically need to be sure the frame rate rarely dips below 360Hz. Put simply, refresh rates have the makings of a technology where more of something is assumed to be better, even well beyond the point it adds any tangible benefit.

HDR in 2020 will likewise continue to be at the mercy of marketing misinformation. You can consult the boxout on the previous pages for more detail on how to make sense of the various standards, what constitutes a true HDR monitor, and how color gamuts come into the equation. But the short version is that you want to look

A COLORFUL YEAR AHEAD

When it comes to HDR PC monitors, not all implementations are equal. But it's not all bad news. Even mediocre HDR brings improved color performance. Strictly speaking, high dynamic range doesn't automatically imply greater color fidelity. Instead, it's about the contrast between the brightest and darkest elements of an image.

However, in practice, HDR standards typically make requirements of a display in terms of color space coverage and color fidelity. Take VESA's DisplayHDR standard. Even lowly DisplayHDR 400 demands 95 percent coverage of the Rec.709 color space (the standard used for HDTVs), 10-bit per channel signal processing, and native 8-bit color rendering. Step up to DisplayHDR 600, and 99 percent of Rec.709 is required, plus 90 percent of the more demanding DCI-P3 color space, the standard for

Stop that, it's silly: Asus's new 360Hz gaming monitor.

Micro LED could be the next big thing, but not in 2020.

out for a display with local dimming and a sustained brightness of at least 600cd/m^2.

On that subject, as 2020 moves forward, you can expect to see displays with more local dimming zones. Early HDR monitors had 300–400 zones. The first displays with 1,000 or more zones are now appearing—Acer's Predator X32 packs 1,152.

With more zones will come better HDR visuals and fewer visual artifacts, such as light bleed or blooming around bright objects. Ultimately, only per-pixel lighting will deliver perfect HDR image quality. That isn't going to be on offer in 2020.

Another area of improvement in 2020 will be pixel response. In 2019, the first monitors with IPS panel tech and claimed 1ms response capability appeared in the form of LG's Ultragear 38GL950G and 27GL850. Those were large, premium models. By the end of 2019, AOC was offering its own more affordable 1ms IPS panel—the 24-inch Gaming 24G2U.

Of course, claimed response times are notoriously unreliable metrics of real-world pixel performance, but it's clear IPS panels are improving and the gap to the fastest TN tech is closing. That's good news if you want speediness and color accuracy in a single monitor. Even in the gaming segment, TN will be increasingly marginalized by higher quality IPS panels.

Overall, then, what will the PC monitor look like in 2020? Condensing the key trends into a single, notional model, sadly it won't beat 4K when it comes to native resolution. Nor will it offer a true high-DPI experience. But it will have HDR capability, albeit flawed, thanks to the limitations of LCD panels, which in turn means it won't be OLED, much less microLED.

It will also offer a wider and more accurate range of colors. It'll be faster by pretty much every metric, be that pixel response or refresh rates. It'll be pretty much any size or shape you desire. Its features will play ball with both AMD and Nvidia graphics cards. And it will hook up to your PC with bandwidth to spare via a single cable providing the display signal, peripheral data, and, if you need it, charging power. The monitor of 2020 isn't quite everything we'd hoped for, then, but it's a pretty fine thing all the same.

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professional digital cinema. DisplayHDR 600 and up monitors also need to support 10-bit color reproduction courtesy of at least dithering technology.

In short, any monitor that qualifies for at least the DisplayHDR 600 certification (there are more demanding DisplayHDR 1000 and 1400 standards) offers wide color gamut coverage. There are, of course, other standards. HDR10 is the standard created by the Consumer Technology Association. It's based around the Rec.2020 color space used by UHD TVs, and if a display conforms with HDR10, it's in about the same ball park for image performance as a DisplayHDR 1000 screen.

The slight confusion, of course, is that a given monitor may be capable of processing HDR10 content, but not capable of rendering its full dynamic range. But a display capable of HDR10 content support but not true HDR rendering, such as the BenQ DesignVue PD3220U, will have wide color gamut coverage. In the case of the BenQ, it achieves 95 percent of the DCI-P3 gamut, which will be sufficient for all but the most demanding professionals.

Even pseudo HDR monitors have improved color coverage.

TECH PORN

PERFORMANCE GEAR LAID BARE

Alienware Aurora R9

DELL'S ALIENWARE BRAND has improved incrementally from its early days as super-expensive gaming hardware bedecked with RGB lighting. The Alienware Aurora desktops have been successful for Dell, and the newest—the R9, with a ninth-gen Intel CPU—is the greatest yet.

The R9 was designed with esports in mind, utilizing a smart design for maximum cooling. Air is drawn in at the front and ejected from the rear, side, and top, with a PSU swing-arm mount that allows for both a relatively compact chassis and improved airflow for the GPU (or GPUs, as the R9 supports the installation of a second card).

The Aurora is prepped for maximum connectivity, with three USB 3.1 ports, a USB Type-C port, plus audio input and output all on the front I/O. Most models of the R9 come VR-ready, and all are equipped with Killer E2500 LAN for high-speed connectivity when gaming. In fact, the Aurora R9 is the rig of choice for esports maestros Team Liquid.

The internal design is impressively compact, fitting in a full AIO cooler with radiator, keeping the CPU (up to an Intel Core i9-9900K, depending on the configuration) perfectly cooled. There's up to 4TB of storage, combining 7,200 rpm hard drives and high-speed NVMe M.2 SSDs. The Z390 motherboard has space for upgrades, whether it's raising your memory capacity or installing a new GPU. Memory speed likely won't need a boost, though, as the R9 comes with 2,933Hz RAM as standard. –**CHRISTIAN GUYTON**

1 LIGHT IT UP

The front features rounded lighting zones that use Dell's AlienFX RGB lighting, with up to 16.8 million colors accessible via the Alienware Command Center software. The app also allows for component thermal monitoring, audio control, and in-OS hardware overclocking—a powerful piece of gaming-oriented software.

2 DOUBLE DOWN

There are five different configurations of the Aurora R9 available, ranging from an $800 model, equipped with an Nvidia GeForce GTX 1650, all the way up to a $4,500 powerhouse, packing 64GB of RAM, along with twin RTX 2080 Super GPUs, with NVLink SLI enabled for maximum graphical power.

3 LUNAR LANDER

The new Aurora is available in two colors, and naturally both of them are space-themed: Lunar Light, the model pictured here, and Dark Side of the Moon, also known to laymen as "black." For no discernible reason, the latter version has one fewer AlienFX lighting zones to customize.

ALIENWARE

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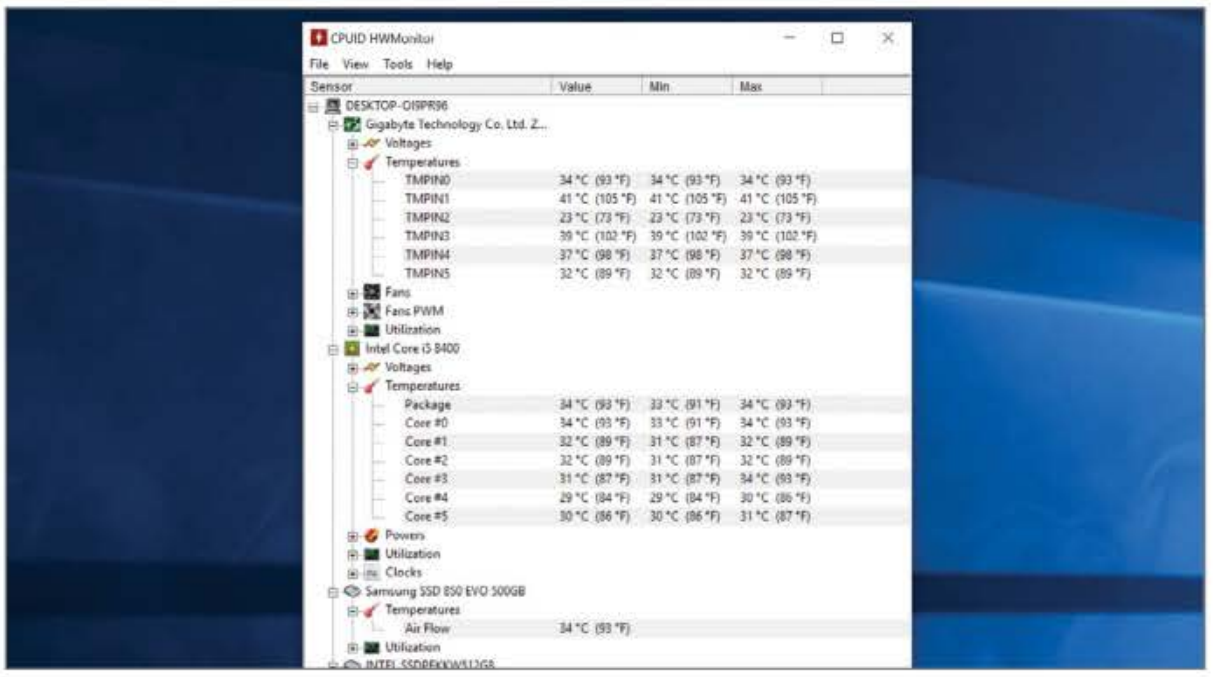
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH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File View Tools Help
Sensor Value Min Max
DESKTOP-OI9PR96
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TMPIN2 23 °C (73 °F) 23 °C (73 °F) 23 °C (73 °F)
TMPIN3 39 °C (102 °F) 39 °C (102 °F) 39 °C (102 °F)
TMPIN4 37 °C (98 °F) 37 °C (98 °F) 37 °C (98 °F)
TMPIN5 32 °C (89 °F) 32 °C (89 °F) 32 °C (89 °F)
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Core #4 29 °C (84 °F) 29 °C (84 °F) 30 °C (86 °F)
Core #5 30 °C (86 °F) 30 °C (86 °F) 31 °C (87 °F)
Powers
Utilization
Clocks
Samsung SSD 850 EVO 500GB
Temperatures
Air Flow 34 °C (93 °F)
Utilization

KNOW YOUR TEMPERATURES

Any seasoned system-builder should know that keeping an eye on your hardware's temperatures using HWMonitor or Real Temp is a must. But it's important to take things one step beyond: Do your research, and find out the actual ideal operating temperature ranges for your CPU, GPU, memory, and storage. Make sure your components are running within those ranges, and they'll last longer and prevent throttling.

CHRISTIAN GUYTON
STAFF WRITER

REARM AND RELOAD

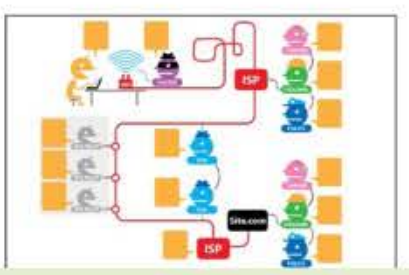
Tensions were high in the office this month, as we attempted to upgrade our esteemed editor's PC, while also building the high-end gaming system featured on the magazine cover. Ultimately, we were successful, but upgrading an entire system is never as simple as you'd think; it's often easier to make those upgrades piece by piece, over a longer period.

Compatibility between CPU and motherboard is a frequent sticking point—just because a mobo can be compatible with a certain processor, it doesn't guarantee that it will be. The board may require a BIOS update (or a reset) first, but a different, actually compatible CPU is needed to do so. This can trip up inexperienced builders as it's rarely highlighted by manufacturers.

Another issue is CPU cooler clearance. Always check that your new cooler or GPU has space to fit inside your case. That said, the listed height of the Cooler Master heatsink I slapped inside our featured build is 166.5mm, while the case lists its CPU clearance as 160mm. Surprisingly, though, it fitted. That reminded me of the more enjoyable aspects of PC building, where experimentation and exploration rule. Sometimes, the only way to find out if something will work is to try it.

MAKE – USE – CREATE

56
Edit video like a professional with OpenShot



60
Stop all browser snooping by using Tor

70
We give a gaming PC a workstation makeover

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IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

Mac Pro 2019

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

The Mac Pro 2019, before we started pulling its insides out.

Even by EATX standards, this board is huge—reminding us more of an Xbox board than ye olde 2013 Mac Pro.

BACKGROUND

The Mac is back and more Pro than ever, throwing away the "trash can" design in favor of something that resembles a computer. Its appearance may hark back to 2006's original, but can it compare in the repairability department?

MAJOR TECH SPECS

- Eight-core Intel Xeon with 24.5MB of L3 cache and a 4.0GHz max turbo frequency
- 32GB (four 8 GB modules) of 2,666MHz DDR4 ECC memory
- AMD Radeon Pro 580X with 8GB of GDDR5 VRAM
- 256GB PCIe-based flash storage module
- 802.11ac Wi-Fi and Bluetooth 5.0

KEY FINDINGS

- We brought plenty of tools, but so far all we need is our fingers. Informative dots tell us the handle rotates, and with ease. The housing slides off with little effort. Inside, we get a peek at the familiar-looking locking mechanism. A closer look reveals pogo pins under the power button that correspond to contacts on the housing. Removing the housing breaks the connection, cutting the power. Neat!
- Unfazed by the ominous array of black modules in the case, we pull the first switch we can find, and voilà! Up pops the first memory cover, revealing two of the four sticks of RAM that came with our model. (There's room for eight more.) Still no tools required—if you have opposable thumbs, you can replace this RAM. The cherry on top is the diagram on the insides of the RAM covers, showing which DIMM slots to populate with different amounts of memory.
- The I/O boards are held in place by Phillips thumbscrews and can be loosened (and tightened) by hand. All PCIe cards are locked in place by a single switch that moves a rail with hooks on it that secure anything in their path.
- The I/O board, video card, and power supply all come out from the same side of the case. We stop to admire all the numbers indicating the order of operations. The power supply is the last easily removable module to come out. It's held in place with a single T8 Torx screw.
- Let's take a look at the custom AMD Radeon Pro 580X video card module: When you pull the release latch, it engages two rollers on the other side, which undock the card and push it away from the motherboard. Unlike the module itself, the silicon inside does not come out with a clever lever. A few screws are hidden under a giant sticker on the cooling fins, and we have to carefully disengage the lever mechanism before we can finally pull out the card.
- Removing the blower fan housing reveals a tiny SSD. We're happy to see a modular SSD, but not happy knowing it's bound to the T2 chip, so user-replacements are a no-go. That said, there are plenty of other ways to add storage.
- Repairability Score: 9 out of 10 (10 is easiest to repair). Basic repairs or upgrades can be done with standard or no tools. Major components are modular and use industry-standard sockets and interfaces, making replacements or upgrades a snap. Apple provides some step numbers and diagrams on the device, and publishes free manuals for some repairs. The SSD cards are modular, but custom-made by Apple, complicating replacement. If you need a replacement that's not on Apple's limited list of approved repairs, you'll likely pay a dizzying price.

Edit Video Like a Professional

YOU'LL NEED THIS

OPENSHOT VIDEO EDITOR
Download this free app from www.openshot.org.

BLENDER
This open-source 3D tool is available from www.blender.org.

INKSCAPE
Use this free app from https://inkscape.org to create titles.

JUST HOW MANY PHOTOS AND VIDEO CLIPS have you accumulated over the years? Whether you've got dedicated equipment or just love snapping and videoing on your phone, now is the time to do something creative with them. OpenShot is a brilliant video-editing tool that's relatively simple to learn, yet packed with features that enable you to turn last holiday's rough video footage into a polished movie you'll be happy to show to friends and family. In this tutorial, we run through the program's main features to help you bring your footage together, edit it, add special effects and titles, and finally export it for sharing with others.

The tutorial has been written for Windows users, but can be easily adapted to work in Linux, too—we recommend downloading the latest 64-bit appimage and running that directly, rather than installing the outdated version of OpenShot through your package manager.

Note: If you're running the current stable version of OpenShot (2.4.4), you need to download Blender 2.79b (www.blender.org/download/previous-versions) if you want to create animated titles with it. If you're running the daily version of OpenShot, it should work with the latest version of Blender (2.80 or later). –NICK PEERS

1 COLLECT AND ADD YOUR FILES

Start by dragging and dropping videos, pictures, and audio to the Project Files pane—a range of formats is supported. Use the "Video," "Audio," and "Image" tabs of the Filter box to filter the view as required. Press Ctrl-S to save your project.

›› You're now ready to start putting your movie together using the Timeline pane at the bottom. Five tracks are set up by default—Track 5 at the top, Track 1 at the bottom. Think of these as layers. Anything placed on Track 1 is your "background," with all other elements appearing on top of it—more on this later.

›› For now, we're going to start with two simple tracks: one video stream containing your video clips (including any sound) and still images, and a separate audio stream for background music. Right-click "Track 5" and choose "Remove," followed by "Track 4" and "Track 3." Click "V" next to a track and choose "Rename Track" if you want to make it more identifiable.

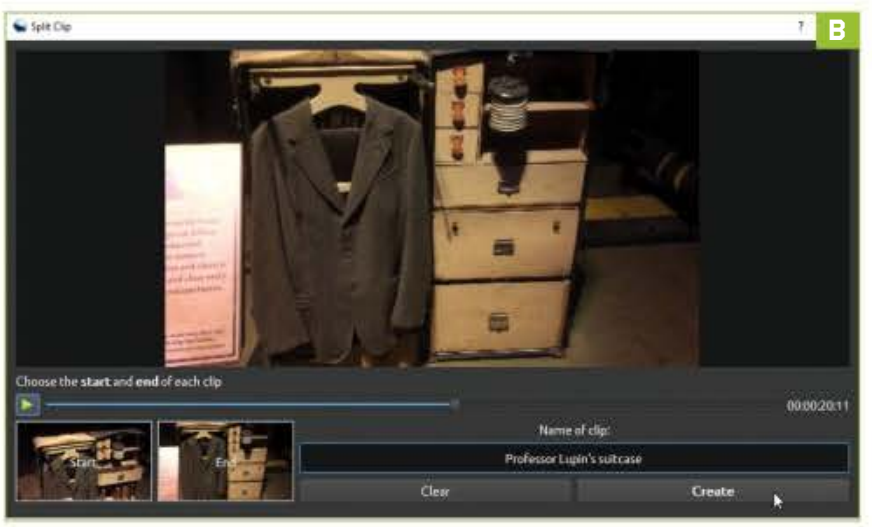
›› Now drag your first clip or image from the Project Files pane on to the video track and place it right at the start of the timeline. Your clip appears as a draggable object, its length corresponding to the duration of the track. The play-head/ruler above the track helps indicate the length of each track, as well as your overall movie. If you're working with short clips, you may wish to adjust the magnification of the ruler; click the "+" and "–" buttons (or drag the slider) to adjust the intervals up or down from the default 15 seconds [Image A].

2 PREVIEW AND TRIM CLIPS

Use the Video Preview window to see how your editing is progressing, providing a rough view of your video and audio tracks, plus any additional effects applied. Use the playback controls underneath or adjust the playback position precisely using the play-head/ruler. Some clips may be perfectly formed, but chances are one or two need trimming, while other, longer files might benefit from being split into separate clips. Why choose the latter option? One reason is to introduce fades or other transition effects within a single clip.

›› It's possible to edit clips directly on the timeline—just position the play-head at the point where you'd like to split your clip, right-click the clip, and choose "Slice → Keep Left Side" to end the clip at that point, "Keep Right Side" to start the clip at the play-head point, or "Keep Both Sides" to split the clip in two. Note that the original clip is left untouched.

›› You can also trim clips from the Project Files pane—a trimmed copy appears next to the original here—enabling you to produce multiple clips from a single file. First, right-click your chosen clip in the Project Files window and choose "Split Clip." Use the slider or click "Play" to locate the exact point where you'd like your edited clip to start. Click "Start" and you



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EXPLORE THE OPENSHOT INTERFACE

1. PROPERTIES PANE
All objects—clips, transition effects, and so on – have their own set of editable properties, accessible here. Double-click an existing value or click and drag left or right inside the value to change it.

2. PROJECT FILES
Drag video clips, images, and audio tracks into this pane to add them to your project. Use the controls at the top to filter your view—right-click an item for additional options.

3. SWITCH VIEW
Use these tabs to switch between viewing project files, transitions, and special effects. Any or all of these can then be dragged on to the timeline below.

4. PLAY-HEAD/RULER
Use this to position the playback preview window at the correct point in your movie. Use the slider above the ruler to zoom into and out of the timeline for finer control or a broader overview.

5. VIDEO PREVIEW
Use this to play your movie—complete with any added effects or overlaid tracks. Click the camera icon to save the currently selected frame as a PNG image file.

6. TRACKS
Place your movie's elements—from video clips to transition effects—on the relevant track to build up your movie. Use the Alpha property on upper layers to make them semi-transparent.

see its thumbnail appear inside the "Start" button. Now position the slider where you want the edited clip to end, and click "End."

›› If you make a mistake or want to change your start and end points, click "Clear" to start again. Give your edited clip a suitably descriptive name to help identify it, then click "Create" [**Image B**]. You see it appear as a new entry in the Project Files window. The

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"Split Clip" window remains open, enabling you to create more edited clips from this video file if you need to. Once you're done, simply close the window.

3 ADD MORE CLIPS (AND PHOTOS)

Now add your second clip by dragging it into place on the timeline. Drag it so it bumps up to the clip or image on its left. Play back your movie and you'll see one clip goes directly into the next. Sometimes this can appear a little jarring. To smooth the switch between each clip, drag the second clip left so it overlaps the first clip slightly—for a couple of seconds, say. OpenShot now automatically applies a fade effect—look for the semi-translucent blue object with a small "V" at the top appearing over your second clip—to ease the transition between scenes. Play back the clip and you should find clip one fades seamlessly into clip two. More on transition effects later.

›› You can now quickly stitch together a rough edit of your basic movie by dragging and dropping clips into position as outlined. Again, use the preview window to

ADD TITLES AND CAPTIONS

No video is complete without a nifty title sequence, and OpenShot has a dedicated tool for creating both static and animated titles. You need Blender for animated ones, and Inkscape for static titles—portable or installed. Once in place, choose "Edit → Preferences → General," and click "Browse" to locate and select the relevant program file.

Once done, select your chosen tool from the "Title" menu. Select a template, then use the controls in the right-hand pane to enter your text and tweak options. Static titles can change font, text color, and background color, while animated titles offer more options, depending on the effect. Be sure to give your title a suitable filename to identify it—after clicking "Save" or "Render," it appears in the Project Files pane, ready for dragging and dropping into your movie. Some titles have transparent backgrounds, enabling you to place them over your video or images, and you can create as many as you like, and place them within the movie, allowing you to add additional elements, such as credits, subtitles, or even a rating to open your movie with.

see how it's progressing—you can use the play and forward/rewind buttons underneath it, or click and drag the play-head (the red vertical line) on the timeline into your chosen position.

4 MORE ADVANCED TRANSITIONS

We've already seen how you can quickly create a basic fade effect between scenes or images by overlapping clips. But OpenShot offers a veritable smorgasbord of different transition effects—hundreds, in fact—all lurking on the "Transitions" tab of the Project Files pane. One way to add these to your movie is to simply select one from the list and drag it on top of a movie clip on your timeline. Too much choice? Click the "Common" button to hide them all apart from a handful of understated wipes, circles, and the previously mentioned fade.

» That's all well and good, but what about the fade effect you created earlier? Thankfully, you can change its transition type without having to delete it and start again from scratch. Click the "V" button next to your first transition and choose "Properties." Right-click the "Source" property (currently set to "fade.svg"), and expand the "Transitions" menu to reveal the common options mentioned earlier [**Image C**].

» Select one of these, then watch a preview on the preview window. Still not what you're looking for? Right-clicking "Source" and opening the "Transition" menu again now reveals all available transitions, split into 18 submenus, ordered alphabetically. Once you've selected a new effect, you can fine-tune it further with all the other available properties. Perhaps the most important one is "End," which sets the duration of the effect. They're 10 seconds by default, so try reducing this to three to five seconds, then previewing the effect.

5 TRANSITION TIPS

While it's tempting to go overboard with these transitions, consistency and simplicity always pay dividends, so find an effect you like, take the time to set it up carefully, then apply it to the rest of your movie. To do this, first delete any other transition effects you've put on the timeline (right-click the transition and choose "Remove Transition"). Now select your original carefully configured transition, and press Ctrl-C followed by Ctrl-V to duplicate it. Drag this new transition into position at the start of the following clip, then repeat the process for all the clips in your movie.

» Generally, one transition is fine, but you can bend this rule for longer movies by setting up a more elaborate effect (a wipe, say) to signal the end of a major scene.

6 ADD EFFECTS TO YOUR CLIPS

When it comes to injecting effects into your video clips, use the "Time" option on the right-click menu to reveal a host of options for speeding up or slowing down the clip, plus running it backward. You can also temporarily freeze (or freeze and zoom) the clip for up to 30 seconds—make sure you've positioned the play-head at the point you want this freeze to happen before applying the effect.

» OpenShot also provides a selection of special effects via the Project File pane's "Effects" tab; 14 are available, including Blur, Color Shift, Hue, and Pixelate. Just drag the effect on to your clip and you'll see a small letter appear next to the filename or clip name—click this to configure it via the Properties pane. Available options vary according to the effect you've chosen.

7 ADD YOUR AUDIO TRACK

If your video comes with its own audio track, this is combined with it on Track 1. You can adjust its volume via the Properties pane—scroll down and experiment with the "Volume" setting. Set it to 0.5 or 0.7 to reduce the volume, or increase it to 2, 3, or 4 if it's too quiet. This should be enough, but it's also possible to extract the audio as a separate clip.

» Right-click the clip and choose "Separate Audio." You'll see two options: A single clip combines all audio channels as one, while if your clip has more than one audio channel (typically left and right), choose "Multiple Clips (each channel)." The audio clips sit on top of the current video clip, so now is the time to drag them off to their own separate tracks. At this point, you need to create new tracks. Click the green "+" underneath "Timeline," then rename the track accordingly. A black square appears over the top of your video—that originates from the audio track. Open the audio track's properties and set its "Scale" property to "None" to remove it. Once done, you can manipulate each audio track independently of the main video track.

» You can also add additional audio tracks—such as a piece of music—to play over your movie. Drag the music file into the Project Files pane if you've not done so already, then switch to the "Audio" tab, and drag the file on to its own track. Preview your movie and you should hear the music track playing over the top of any audio in your original clips.

» Again, you can adjust the volume of your music track using the "Volume" property, but manually tweaking different audio tracks can be awkward, particularly in relation to other tracks. A semi-automated solution is available in the form of the "Volume Mixing" property. For example, to give your soundtrack prominence over the background audio, set its "Volume Mixing" property to "Reduce" [**Image D**], then select each video clip on Track 1 in turn, and set its volume mixer to "Average." If you'd prefer the music to be in the background, reverse the settings.

ADD PHOTOS

Drag a photo on to the timeline and it appears in your movie for 10 seconds by default; choose "Edit → Preferences → General tab" to edit this via the "Image Length (seconds)" setting. We recommend overlapping images to produce a more seamless switch between them using the Fade effect.

Image-based slideshows can appear rather static, even with the transition effects in place. One way to inject some more pizzazz is to make use of OpenShot's various Animate effects. Right-click the photo to reveal a pop-up menu of options. Use the "Rotate" menu to correct the orientation of portrait photos, then examine the options under "Animate."

One potential issue with rotated photos is that the top and bottom get chopped off. One solution is to use "Animate → Start of Clip → Zoom → Zoom out (100% to 75%)," but another is to edit the clip's properties: Right-click it and choose "Properties." In the Properties pane, click and drag the "Location Y" slider right to pull the image down, or left to pull it up. Alternately, double-click inside and enter a figure manually—try -0.15 or 0.15. Use the "Scale X" and "Scale Y" figures to crop further.

8 FINISHING TOUCHES

Thanks to OpenShot's support for multiple tracks, you can experiment with placing images, captions, or video clips on top of other clips—create a new track, drag your content on to it, and watch as it blocks out the video track completely. You can adjust its transparency using the overlaid element's "Alpha" property (try 0.5 for a semi-transparent effect), or experiment with other settings, such as adjusting its size or position. Alternately, the Chroma Key effect is a rough and ready way to introduce green-screen effects by removing plain backgrounds. Just select your "Key Color" from the effect's Properties, and use the "Fuzz" property to refine the edges [**Image E**].

» If you want to add text to your movie—in the form of a title, subtitles, or explanatory captions, say—check out the box opposite on adding titles. Use the static title tool to generate captions—most come with transparent backgrounds, enabling you to lay them over the top of your video clips without blocking them out.

9 EXPORT YOUR FINISHED VIDEO

Once your movie is complete, choose "File → Export Video." Most of the options here are self-explanatory—choose a file format (the universal MP4 with h.264 codec in most cases), video profile (frame rate and resolution size), and quality setting. For best results, try to match the initial resolution of your video clips—failing that, try a lower quality setting. Finally, click "Export Video" and sit back. This can take some time to complete, even for a relatively short video, and depends on the speed and spec of your PC. A progress bar and estimated time until completion tell you how long you've got to wait, but the conversion rate will vary at certain points in your movie.

» The progress bar speeds up and slows down during points of the conversion based on the number of tracks being processed, but in all likelihood, you'll need to make a cup of tea for even a relatively short clip. If your exported movie experiences playback issues, try exporting again using different presets. Still no luck? Scale back the number of effects, or investigate upgrading your PC to handle the demands of video editing better. Look for a modern multicore processor, a minimum of 8GB of RAM, and a fast SSD drive.

Stop All Browser Snooping with Tor

YOU'LL NEED THIS

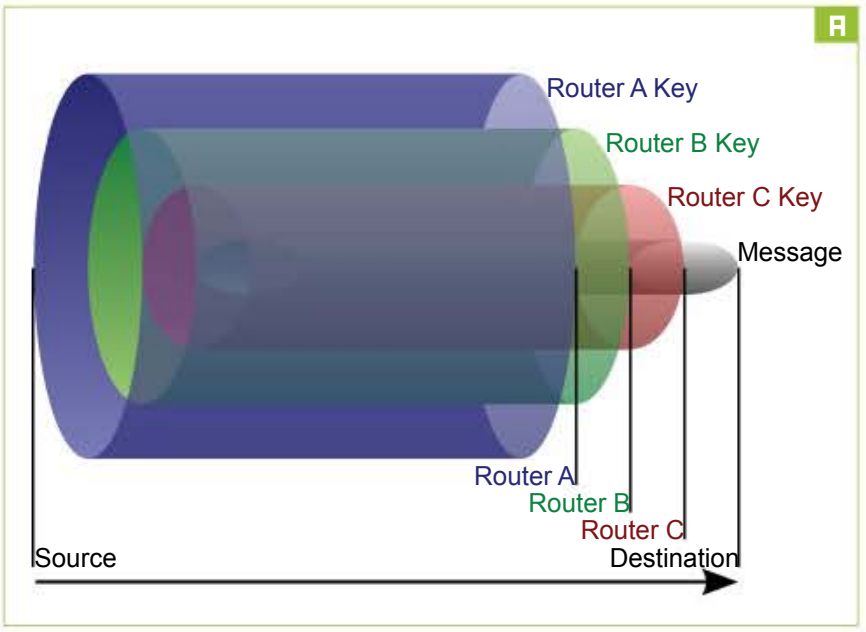
THE TOR BROWSER
Download it from www.torproject.org.

THEY'RE WATCHING YOU. They're watching everything you do online. You'd think we were being paranoid, but it's part of their mission statement; the US government is part of the international Five Eyes (https://en.wikipedia.org/wiki/Five_Eyes) group of Australia, Canada, New Zealand, United Kingdom, and United States, which have worked together since World War II to collate and share intelligence, and that includes the Internet use of citizens.

In the digital age, that means intercepting, storing, and analyzing all Internet traffic. Don't be fooled into thinking that local laws can stop a nation state from spying on its own citizens. If you're one of the Five Eyes, just get your buddy overseas to do the spying, then report back. Tempora (https://en.wikipedia.org/wiki/Tempora), a UK program, splices off the undersea fiber-optic backbone of the Internet, duplicating all the data transmitted over it, with the NSA sharing that data. Damn crafty, those Brits, described by Edward Snowden as "worse than the US."

But back at home, programs such as PRISM created a legal framework for the NSA to spy on targeted US citizens, immunizing co-operating US companies from prosecution. Or take MUSCULAR for bulk copying of Google and Yahoo! data to outside of US territory, for the NSA and GCHQ to rifle through at their leisure. And who knows what Russia, North Korea, and China are up to....

It's not paranoia if it's actually happening. The good news is that the open-source community has brought together a host of privacy technology to offer a verified solution: Tor. **–NEIL MOHR**



1 TOR GUIDE

Tor (or, as it used to be known, The Onion Router) is a collaborative, open-source project designed to provide anonymous access to the Internet. An easy way to think of it is as a browser VPN that anyone can use.

» That's a good starting point, but what's wrong with your current VPN service? It says it offers you privacy and anonymous browsing, right? Yes, but how do you know it actually does? If it's a US-based commercial service, the VPN is at the mercy of the US government, and can be gagged by existing legislation while the state rifles through its servers.

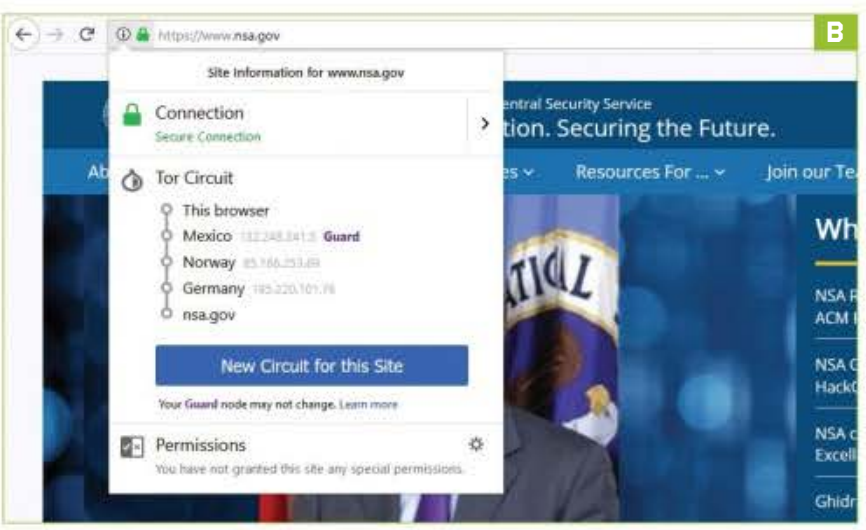
» Or how do you know your VPN isn't run by some guy sitting in a basement somewhere, dressed in a onesie, while he watches anime? This isn't to say VPNs are useless, it's pointing out that they're not a silver bullet. If no third parties test their systems for security or flaws, how do you know they're secure at all?

» This brings us back to Tor and what it can do for our online privacy. It might help to very quickly say why you don't have online privacy in the first place, beyond the notion that every government in the world is probably monitoring you online. It's largely down to how the Internet was developed and has to be run. The Internet is a precarious stack of open protocols built up over decades, and back in the 1960s, everything was done in plain text—that didn't change for a very long time; HTTP is transmitted in plain text.

» Even today, the domain-name routing of your browsing and email message headers remains open to scrutiny, and if you want the Internet to be worldwide, you have to allow data packets to be passed across borders—this enables nation states to do some dubious rerouting of entire tranches of data, which also strengthens the argument for a system such as Tor. But what exactly is that system?

2 STINKY ONIONS

The whole reason Tor was originally called The Onion Router is that your data and destination address are locked up inside an onion of encryption. As



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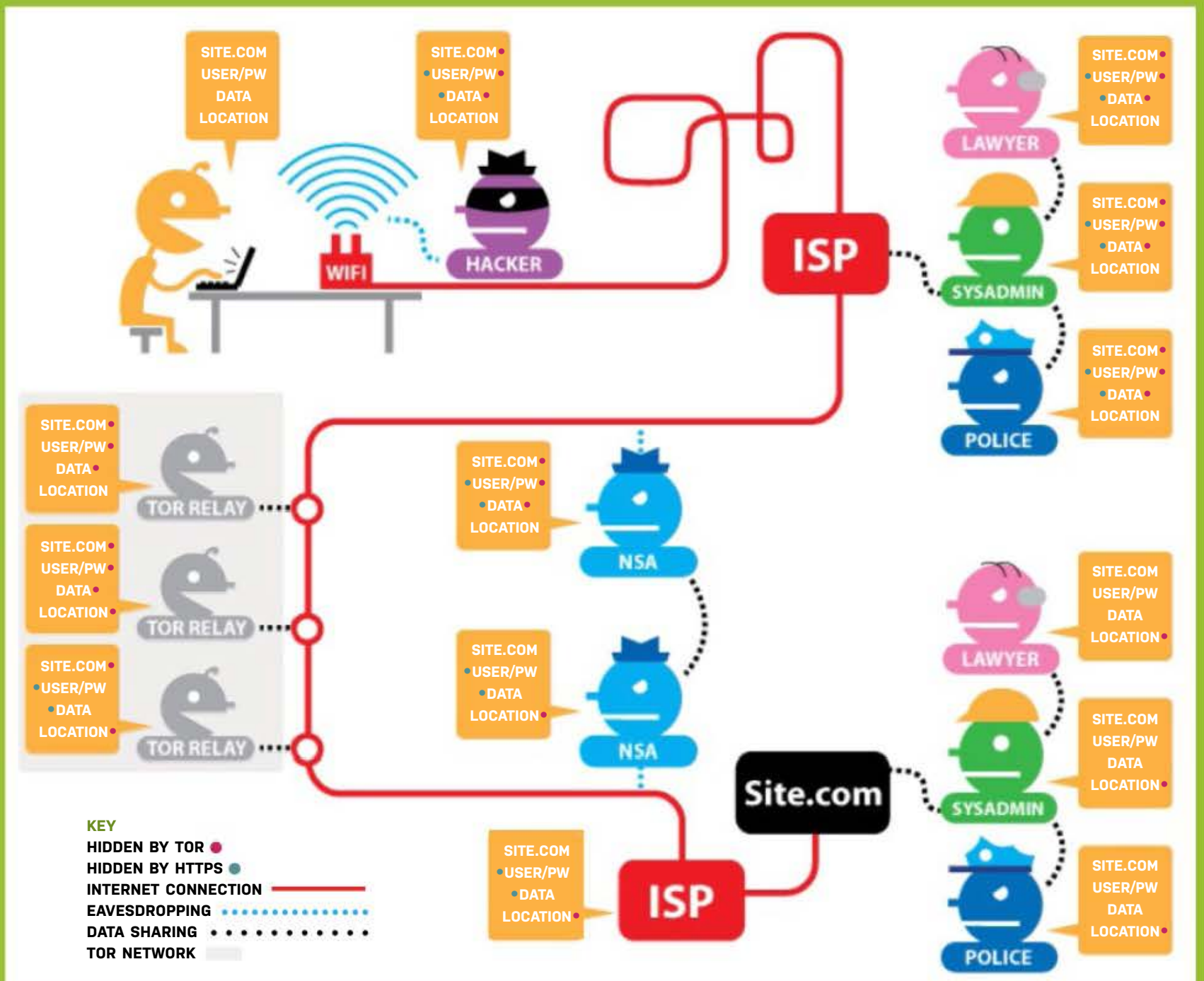
TOR AND HTTPS IN USE



Take a look at how much privacy protection Tor and HTTPS offer when used. Without either Tor or HTTPS at every step in the process, anybody with access to your connection can potentially snoop on all your activity, including the destination site, your username and password, your user data, and your location.

Using HTTPS helps to protect your user data, and your username and password at all stages.

Using Tor masks your destination site, username and password, data, and, to a certain degree, your location. Adding a VPN would further protect your location details, but we should point out that there could be government bodies directly accessing ISP data or the site.com services via unknown snooping programs.

your data packets move through the Tor network [Image A], each relay node unpeels one layer of encryption, which points to the next node, until the final exit node is reached, and the unencrypted data is passed to the end destination.

» So, the entry node doesn't know what the data is or where it's going, but keep in mind it does know where you are. Intermediate relay nodes don't know where the data is going or what the data is, while the final exit node doesn't know where the data has come from, but it does know the destination, and it can interrogate the data unless you're using a secured HTTPS site. Of course, you also need to bear in mind that the final destination can know everything about you if you're not taking care to anonymize yourself correctly.

3 USING TOR

If we were pedantic, we'd point out that if you're truly worried about privacy, you should dump Windows and switch to Linux, but let's stay in the real world. The Tor Project has done a grand job of making it super-easy to install and run; it's not much more complex than going to www.torproject.org, grabbing the installer, running that, and using the Tor Browser.

» You can ignore the "Configure" options when Tor is first run—they're for connecting via a proxy, and can be set from within the browser later if need be.

» If the Tor browser looks familiar, it's because it's a respin of Firefox, tooled to work directly with Tor,

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GOING ON TOR

While we might have talked about using "portable" versions of Tor in terms of releases you can take with you on a USB drive that will run on any PC, what about mobile devices? The double good news is that, over recent years, the Tor Project has come on in leaps and bounds with regard to Android and iOS apps. Previously, it took a similar multi-tool approach to mobile as it did for PCs, but thankfully, it's all now wrapped up in a single easily installed package called the Tor Browser—ignore Orbot, that's the old release.

Just download the Tor Browser and it works the same on your cell phone or tablet as it does on your PC. It's available via the standard Google Play Store or direct as an APK from the Tor Project itself at https://www.torproject.org/download/#android (you need to know whether your device is a 64-bit or 32-bit Arm device).

Due to Apple policies, the Tor Project on iOS has had a bumpy time, but it's available as the Onion Browser, which works a treat, and is right up to date. You can grab it from https://apps.apple.com/us/app/onion-browser/id519296448.

offering specific settings, pre-configured plugins, and security certified to be as secure as possible out of the box. A regular warning is not to use random plugins or indeed other browsers (especially Chrome) over Tor, because you have no idea what tracking they might have implemented within them. However, there are two default plugins that we'll cover shortly, explaining why they're so handy.

» The Tor Browser is basically a locked-down build of Firefox. By default, it forgets and wipes everything from session to session, because it's in what it calls "Permanent private browsing mode." If you're after a more casual browsing mode, you might want to select "Menu → Options → Privacy & Security," and disable "Always use private browsing mode" under "History." This forces a restart, and retains cookies and your browsing history—if you're after higher anonymity, this is not recommended.

» Moving security in the stronger direction, the Shield icon in the toolbar—or within the "Menu → Options → Privacy & Security → Security" section—offers three distinct security levels. It defaults to Standard, which is frankly pretty secure, but it does still enable JavaScript, which many distrust. The annoying issue is that most websites require JavaScript to run, so if it were disabled, Tor would be mostly useless to the average user—it's a trade-off between usability and security.

» The next security level of Safe does indeed turn off JavaScript for all sites that can't use the encrypted HTTPS mode, while it disables audio, video, and WebGL unless you click to allow them. The highest level disables JavaScript entirely. And don't even ask about Flash—you are, aren't you? Flash is a security nightmare at the best of times, so Tor just won't go there. In general, the advice not to run third-party plugins is down to the fact that you have no real idea what data they could transmit back to base. However, Tor does use two well known plugins.

» To help secure your connections, Tor makes use of two widely used browser plugins: HTTPS Everywhere and NoScript. HTTPS is a version of the standard HTTP plain-text protocol that's been encrypted. This instantly means no one can read the data traveling between your PC and the destination server. However, it's not always enabled by default, hence the use of the plugin to do just that—however, it can't enable HTTPS on sites that don't support it at all. The NoScript plugin offers per-site control over almost every aspect of the code run by that website. Tor makes use of this to restrict or disable code that could leak data about yourself.

4 IDENTITIES AND CIRCUITS

When you first connect to the Tor network, this is called your initial "Identity"—basically, all data is sent to the same entry node for a set period of time (usually two or three months), before you're automatically cycled to another. The series of encrypted server hops after this, and the exit node, is called the circuit. When connected to a website, click the "i" icon at the start of the URL address bar to see the established Tor circuit, along with an option to reset this [Image B].

» Tor offers two ways to reset the circuit or the Identity. The basic option is the Tor circuit—this most often crops up when an exit node IP has been banned by a service. Choosing a new circuit provides you with a new exit node. It causes the currently active tab or window to be reloaded over a new Tor circuit. Other open tabs and windows from the same website will use the new circuit as well once they are reloaded.

» Selecting a "New Identity" takes this a step further. Alongside requesting a new entry node, it closes all your open tabs and windows, clears all private information, such as cookies and browsing history, and uses new Tor circuits for all connections. It's like restarting the browser as well as your router.

5 WEIRD BROWSING

We should highlight some of the more common issues you can run into when browsing the web from the view of a Tor exit node. Exit node IPs get flagged up for all manner of nefarious reasons, so if a site or service sees you're coming from an exit-node IP, it'll likely trigger a red flag and additional security checks on you, which you wouldn't experience browsing normally.

» One common annoyance is repeated captcha challenges. Where you might be used to getting one normally, expect multiple challenges before you're allowed access to a service or website. Also, some websites turn up in foreign languages—again, this is down to whatever location your Tor exit node is located

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in. Most sites base your location on this IP, then serve up their site or service in that language. You just have to switch the site using any offered language preferences.

›› You might get messages saying that your IP is blocked, or warnings that your account or system may have been compromised. Again, this is down to unscrupulous types abusing the Tor system and giving exit-node IPs a bad name. Typically, using the "New Identity" option can solve these issues.

6 RUNNING NODES

We mentioned various types of nodes, which is a fancy name for a server or PC running Tor in a special mode. By default, you run Tor in client mode—you're only accessing the Tor network, rather than helping to run it. The network itself is made up of three node types: entry, relay, and exit. The most widespread are relay nodes, the intermediary nodes that pass encrypted onion packages within the Tor network [**Image C**]—technically, when you install the Tor Browser, you have everything required to run one, but we're not going to cover this. An entry node is simply a relay node that's run for long enough (68 days) and proved to be reliable enough for the classification upgrade.

›› An exit node is where Tor traffic re-enters the standard Internet and is sent on to its destination. If you wanted, you could run an exit node, but this is not recommended. Due to the nature of the traffic, exit nodes can draw the ire of not only your ISP, but also local law enforcement. The Tor Project advises you to inform both your ISP and local authorities that you're running an exit node to avoid such issues. So, it's not something you should do on a whim or with company servers.

7 THE DEEP, DARK, DINGY WEB

So, Tor implements a network within the Internet network, and just like the Internet, the Tor network can and does have its own network of anonymous websites that get called various things, such as the dark web or deep web, along with Tor Hidden Services. There is a whole unseen world of .onion anonymous websites that live within the Tor network.

›› You're able to access sites with https://<16-character hash>.onion—as an example, Facebook has an onion service at https://facebookcorewwwi.onion that enables people living in oppressive regimes to still use Facebook [**Image D**]. Or DuckDuckGo offers an onion site at https://3g2upl4pq6kufc4m.onion.

›› As you can imagine, a good chunk of the dark web is taken up by illegal activities, but that certainly doesn't mean there's no room for good elements. You can find a reasonable list of legal sites at https://github.com/alecmuffett/real-world-onion-sites.

8 STAY SAFE OUT THERE

Tor isn't a magic bullet to complete online privacy or anonymity—if you do something silly, you will expose yourself to anyone monitoring. A simple example is that if you log into a service via Tor using your real identity, that service and any bodies that are able to monitor that service can then identify you. It's the same situation if you make payments with accounts linked to your real identity, which is why Bitcoin and other cryptocurrencies are popular.

›› Sharped-eyed readers might have spotted we mentioned that entry nodes (aka guard nodes) do know your real IP, although they have no idea where your data is going. However, this has led to speculation that government-run entry nodes could collate logs that tally with exit node traffic, among other advanced techniques, to monitor Tor users. This leads some people to running a Tor-over-VPN combination, which certainly would remove this one weak element in the Tor system.

›› This particularly applies to Google services, searches, and accounts. It's strongly recommended to only use DuckDuckGo for search when on Tor, as it has a reputable record of not tracking its search users, while Google absolutely does track you. This extends to not using the Google 4.4.4.4 and 8.8.8.8 DNS services.

CHASING YOUR TAILS

What happens if you're out and about and want to access the Tor network, but on someone else's PC? This could be at an Internet cafe or perhaps using a work system where you can't install software. Say hello to Tails, an open-source OS project that integrates Tor. Based around a Linux distro called Debian, Tails provides an ISO disk image that you can install to a DVD or USB sick. This can then be booted directly by most PCs, and the OS runs straight off the drive.

This gives you direct access to all the usual tools you'd like, alongside Tor browsing, but once you're done, just power down and remove the stick, and all traces that you were ever there will be gone.

To get started, head to **https://tails.boum.org**, and click "Download." It offers step-by-step install instructions for Windows, Mac, and Linux, but you basically need to grab the ISO, and use Etcher to write the image to a USB drive.

To run Tails on a PC, you must select the boot drive when the PC is first powered up at the BIOS/UEFI. Many systems offer an early "Boot" menu, accessed by tapping F9 (HP), F12 (Dell/Lenovo), F8 (Amibios), or F11 (Award BIOS) while powering up. Look for your USB device, and off you go!

© TAILS, FACEBOOK

Recover Deleted Data with Disk Drill

YOU'LL NEED THIS

DISK DRILL 2
Sign up at
http://win.cleverfiles.com.

IT'S SOMETHING THAT HAS HAPPENED to all of us at some point—the horrible realization that a file you need has vanished, maybe deleted, and the Recycle Bin emptied.

With Disk Drill 2, you can get your data back. *Maximum PC* readers can download a full copy of this advanced file recovery tool and use it for 18 months completely free of charge—check out the tutorial below to find out how. If you are impressed by what Disk Drill 2 is capable of, we've teamed up with CleverFiles to bring you the latest version, Disk Drill 4, with even more advanced features, at a 30 percent discount.

To take advantage of this offer, download the trial version of Disk Drill 4 from www.cleverfiles.com/disk-drill-windows.html, then opt to upgrade it to the full version, using the discount code (MaximumPC) at the checkout. –MARK WYCIŚLIK-WILSON

1 DOWNLOAD AND INSTALL

Readers of *Maximum PC* can download a special version of Disk Drill 2 from the developer's website—just go to http://win.cleverfiles.com/disk-drill-win2.msi in your web browser. Once you've downloaded the file, double-click it to start the installation, and click "Next" to continue. Make sure you opt to install the software to a partition other than the one you want to recover data from, then complete the installation.

2 ACTIVATE

At first, Disk Drill 2 runs with limitations, such as only being able to recover up to 500MB of data. As a reader of *Maximum PC,* however, you can unlock the full version for 18 months. Click the "Activate" button in the splash screen or the settings menu (the gear/cog icon), and select "Enter activation code." Type in "22485-59692-589F6-5A537-42521" without the quotes [**Image A**], then click "Activate."

3 SELECT RECOVERY DRIVE

You now see a list of all of the hard drives you have installed in your computer, and all of their partitions [**Image B**]. Choose which drive or partition you want to scan for recoverable data—either specific files you know the location of, or just to hunt for anything that is recoverable. Click the down arrow next to the corresponding "Recovery" button, and you'll see a list of available options.

4 PERFORM A QUICK SCAN

Try a quick scan of your selected drive first—click this option in the menu. Despite the name, this process may take some time, but just how long depends on the size of your hard drive and the amount of data on it. You can continue to use your computer while the scan is running, but if you find the scan slows you down too much, you can click the "Pause" button [**Image C**] to temporarily halt it.

5 PERFORM A DEEP SCAN

A more thorough option is to perform a deep scan—this can take significantly longer than a quick scan, but Disk Drill is far more likely to be able to find recoverable data this way. There is little for you to do except sit back and wait while the progress bar lets you know how things are going, and in the upper-right corner, you'll see an estimate of how much time is remaining [**Image D**].

6 SAVE AND RESTORE SCANNING SESSIONS

If a scan is taking a very long time, and you'd like to save it so you can come back later, pause the scan, then click "Save Session" at the top of the screen, and enter a name for the saved session [**Image E**]. You can return to this at a later date by selecting the "Continue" option from the main drive selection screen.

7 BROWSE SCAN RESULTS

Once the scan is complete, any files that have been found are grouped by type. You can browse these results just as you would files and folders in Windows Explorer, and you can mark individual items for recovery by checking the box next to them. You can also treat file types that are grouped together as a folder, checking the relevant box to select all of a particular type of file [**Image F**].

8 FILTER AND SEARCH RESULTS

If you are having trouble locating a particular file by browsing, there are various ways to home in on them. You can use the "by size" and "by date" options to the left [**Image G**] to filter files according to how big they are and when they were created—useful if you know when you saved a file. You can also use the search box to the left to look for specific files by name.

9 RECOVER DATA

With one or more files selected, click the folder icon to the right of the blue bar. You can then select the folder—ideally on a different hard drive or partition—to which the recovered files should be saved. Click the "Recover" button at the upper-right of the program window, and your lost files will be restored, ready for you to view and work with again [**Image H**].

10 DISK DRILL PROTECTION

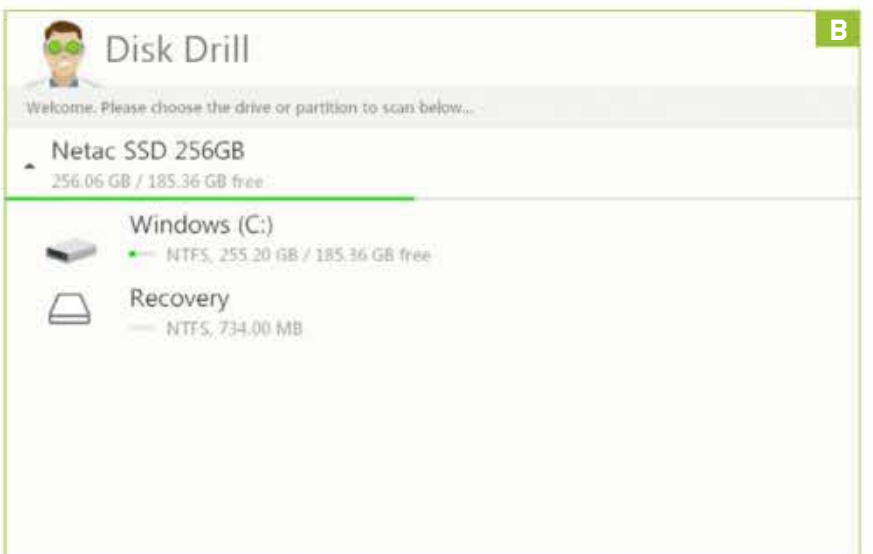
Disk Drill includes a handy feature that can be used to secure your files against loss in the future. On the main screen, click the "Protect" button to the right of a drive, and click "OK" when asked. To the upper-right of the screen, toggle the "Recovery Vault" switch to the "On" position. Your "Documents" folder is protected by default, but you can add more if you want.

© DISK DRILL

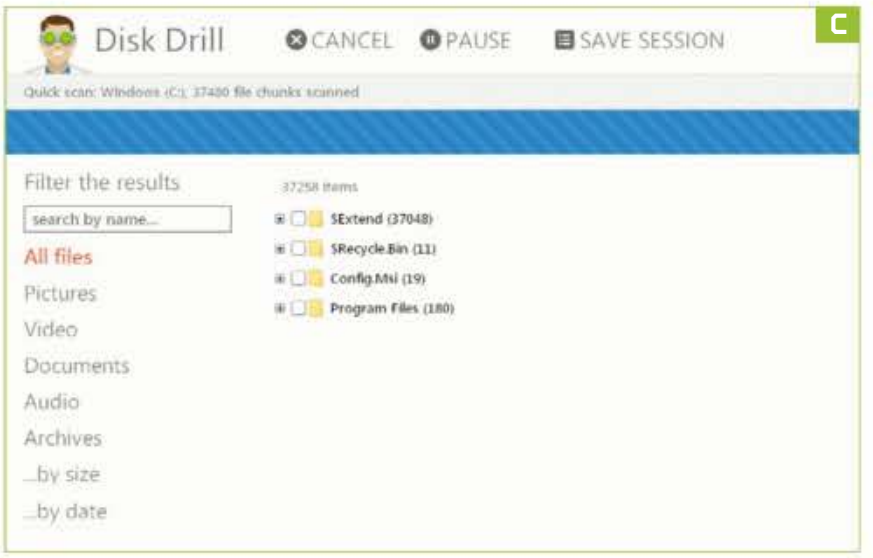
A

Disk Drill
Netac SSD 256GB
Windows (C:)
Recovery
Enter Activation Code
Activate your PRO or Enterprise version
22485-59692-589F6-5A537-42521
Cancel
Activate
Upgrade now

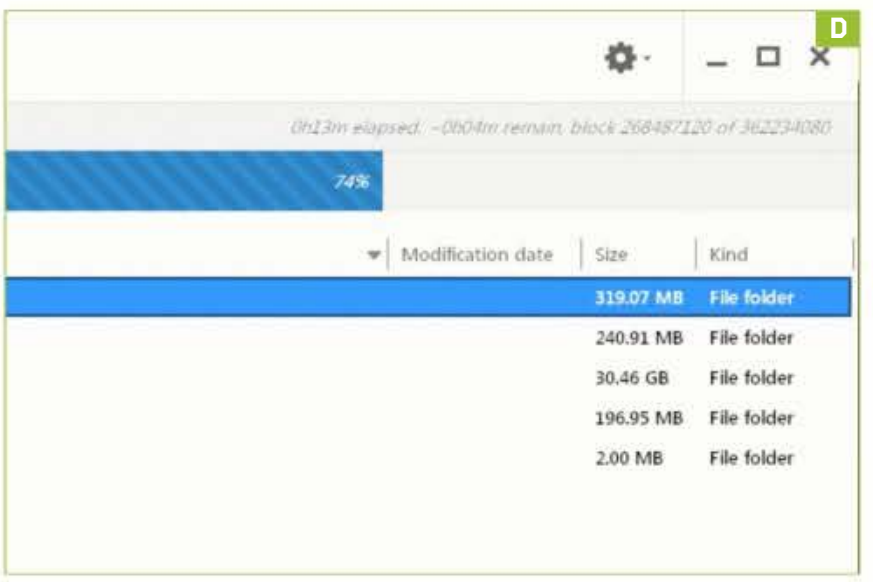
B


Disk Drill
Welcome. Please choose the drive or partition to scan below...
Netac SSD 256GB
256.06 GB / 185.36 GB free
Windows (C:)
NTFS, 255.20 GB / 185.36 GB free
Recovery
NTFS, 734.00 MB

C


Disk Drill
CANCEL
PAUSE
SAVE SESSION
Quick scan: Windows (C:), 37480 file chunks scanned
Filter the results
search by name...
All files
Pictures
Video
Documents
Audio
Archives
...by size
...by date
37258 items
SExtend (37048)
SRecycle.Bin (11)
Config.Msi (19)
Program Files (180)

D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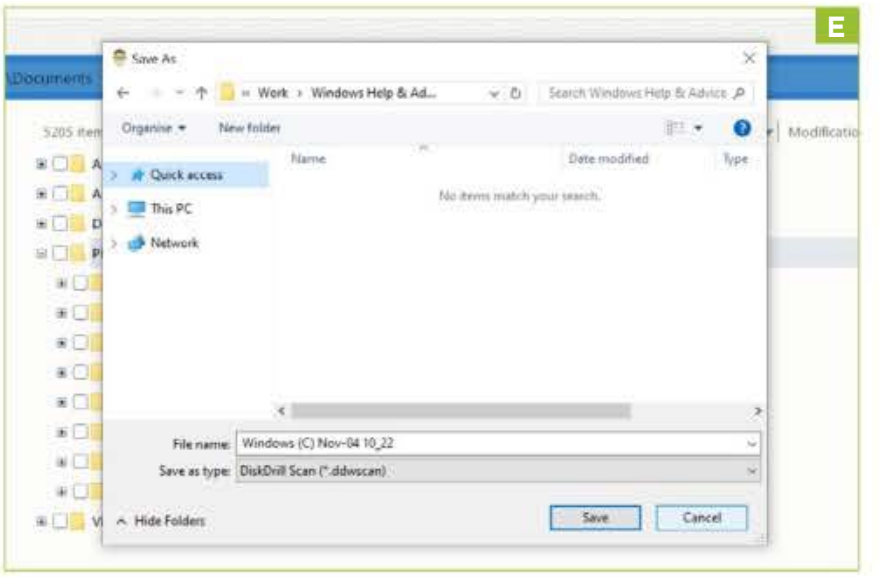
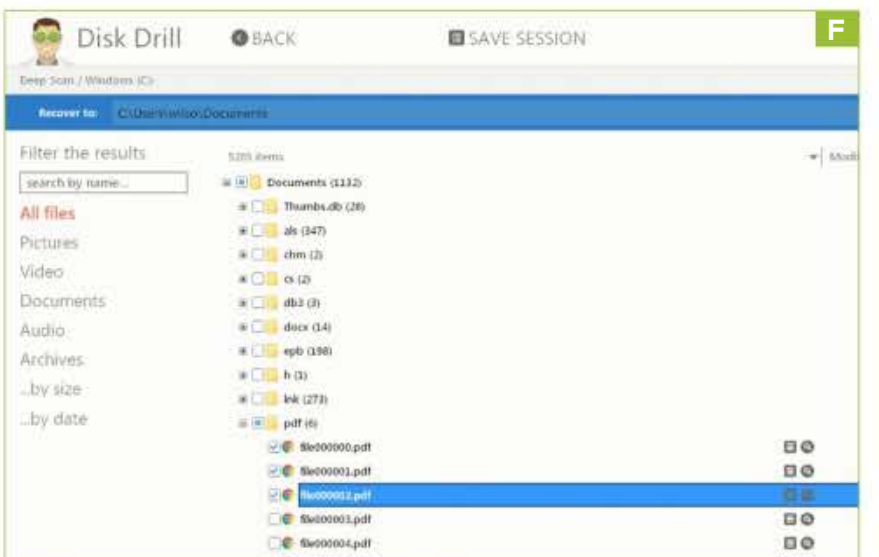
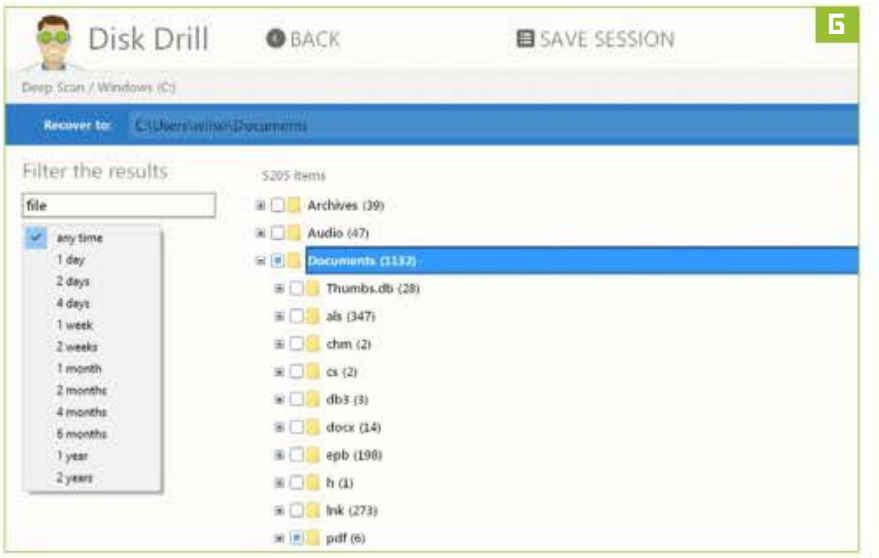

Save As
Work › Windows Help & Ad...
Search Windows Help & Advice
Organise
New folder
Quick access
This PC
Network
Name
Date modified
Type
No items match your search.
File name: Windows (C) Nov-04 10_22
Save as type: DiskDrill Scan (*.ddwscan)
Hide Folders
Save
Cancel

F


Disk Drill
BACK
SAVE SESSION
Deep Scan / Windows (C:)
Recover to:
Filter the results
search by name...
All files
Pictures
Video
Documents
Audio
Archives
...by size
...by date
Documents (1132)
Thumbs.db (28)
als (347)
chm (2)
cs (2)
db3 (3)
docx (14)
epb (198)
h (1)
lnk (273)
pdf (6)

G


Disk Drill
BACK
SAVE SESSION
Deep Scan / Windows (C:)
Recover to:
Filter the results
file
any time
1 day
2 days
4 days
1 week
2 weeks
1 month
2 months
4 months
6 months
1 year
2 years
5205 items
Archives (39)
Audio (47)
Documents (1132)
Thumbs.db (28)
als (347)
chm (2)
cs (2)
db3 (3)
docx (14)
epb (198)
h (1)
lnk (273)
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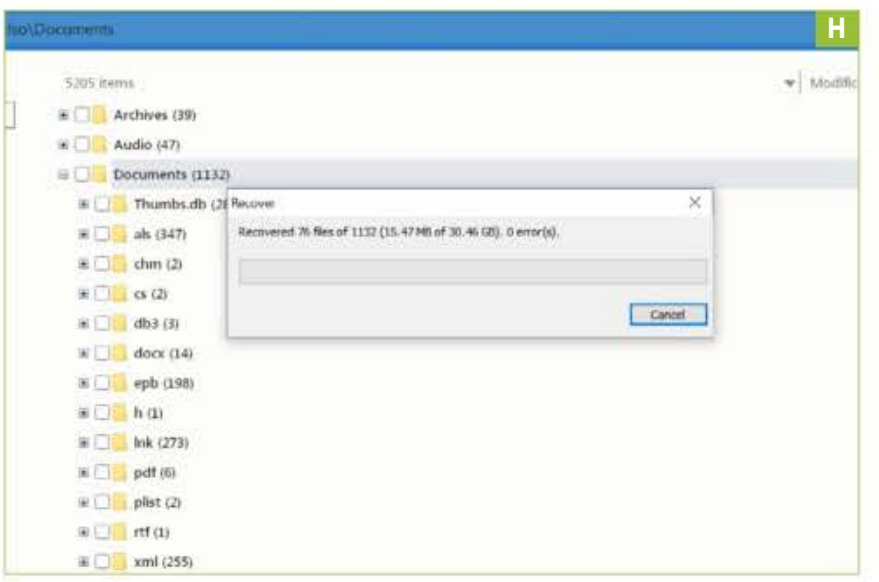
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Machine of the Month: the BBC Micro (1981)

YOU'LL NEED THIS

WINDOWS OR LINUX PC
These emulators run on any modern PC, but Linux users need a stable version of Wine.

JOYSTICK
A USB joystick makes life easier in some games.

YOU MAY NEVER HAVE HEARD of the BBC Micro, but in '80s Britain, this beige box with its cool red function keys would find its way into almost every school in the nation. For many Brits, the BBC Micro would be their first experience using a computer, inspiring new coders across the country. With a production run reaching into the mid-'90s, it was a national institution. Indeed, it was the BBC Micro that inspired both the Raspberry Pi and its Model A and B naming scheme.

Although the BBC Micro was too expensive to be a popular home games machine, those who indulged it were rewarded with a beautiful version of BASIC and lots of great games, such as *Chuckie Egg, Exile, Citadel,* and *3D Dotty.* Nevertheless, BBC Micros are hard to find in the US (never mind the issues with power supplies and PAL to NTSC conversion), leaving emulation as Americans' only real option. So, join us as we take you through a history of the BBC Micro, and provide instructions for getting you gaming in the fastest, most painless way. **–JOHN KNIGHT**

1 BATTLE FOR THE BBC

The BBC Micro was born out of fierce competition between British computer makers. Worried that Britain would be left behind in computing, the government designed a national computer literacy project. Planning a BBC television series—*The Computer Programme*—this would be tied to a specific computer, which would be bought for schools.

›› Winning such a contract would be enormously lucrative, with every maker putting in their bids. Ultimately, it boiled down to two competitors: Sinclair Research and Acorn Computers. Sinclair Research was led by famous British inventor, Clive Sinclair. Acorn Computers was led by ex-Sinclair employee, Chris Curry. Curry had left Sinclair on unfriendly terms, and for several years, the two firms had a bitter rivalry.

›› When the BBC came calling, Sinclair's proposed model had a cheap rubber membrane keyboard, which simply didn't suffice, leaving Acorn the only convincing bid. However, the proposed model didn't actually exist, and Acorn only had a week to build it.

›› Most of the Acorn team was convinced the task was impossible, but by stripping down an existing Acorn prototype (the "Proton") and working through the night for the next week, they just about managed to cobble together a working prototype by the last minute. The BBC was suitably impressed, and Acorn won the contract.

›› Built with schools in mind, these machines have an extremely rugged case, with only a keyboard in view for kids to bash around. Switch on the machine and you're immediately greeted with a BASIC prompt, ready to code from the get-go. Look behind the machine and there is an enormous number of connectors and expansion options, with modifications being common among serious users.

›› On launch, there were two models: the Model A with 16K of RAM, and Model B with 32K. The Model B is more common. Although generally too expensive for families, the Micro found its way into the majority of British schools.

2 GAMING

Despite being on national television and installed in most schools, the Micro was uncommon in homes, losing out to Sinclair's ZX Spectrum and its enormous game library. However, 1984's *Elite* earned the Micro its place in gaming history. An astonishing achievement for the time, people could now explore an entire galaxy in wireframe 3D—all in something smaller than most JPEGs. An imperious game for an imperious machine.

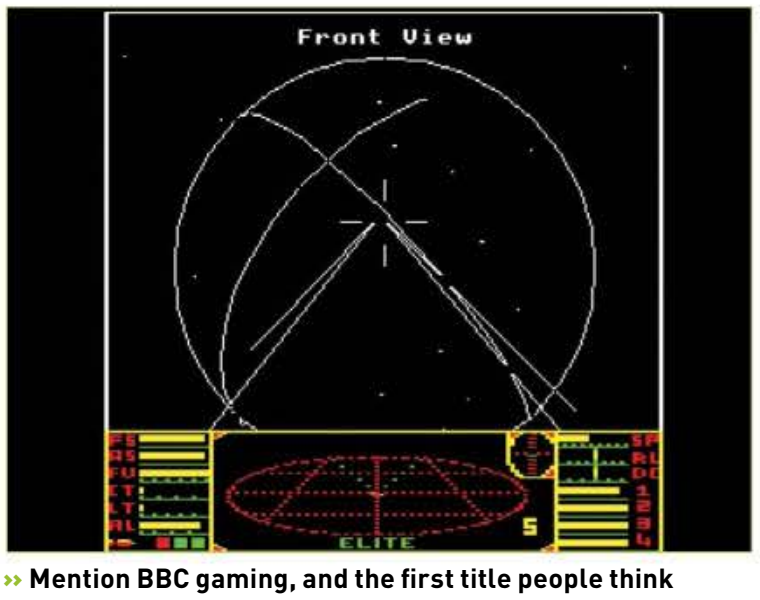
›› Coming from an early era of home gaming, most Micro games have a feel somewhere between an original Atari and a Commodore 64 (despite the BBC having a faster CPU than either). Later games became more advanced, such as *Impossible Mission, The Sentinel,* or *Stunt Car Racer.* Graphics are generally better than a Spectrum, but not as good as a Commodore.

›› Recognizing the potential of the gaming market, and wanting to appeal to home users, Acorn released a cut-down version of the BBC Micro: 1983's Acorn Electron, which was a moderate success. Most commercial releases are written with both machines in mind.

3 HOW TO EMULATE IT

For the best emulators, our two choices are BeebEm and Horizon. BeebEm is the easiest to use, and runs UEF tape files, but may not run everything. Horizon is a bit trickier to use, but has features such as automatic key remapping. Overall, we recommend installing both. Each program covers the other's gaps nicely, and between the two, most titles should work.

›› Note: The BBC Micro doesn't have arrow keys. Games often standardize on either A, Z, <, and >, or :, /, Z,



›› Mention BBC gaming, and the first title people think of is usually 1984's *Elite.*

›› You're unlikely to have used a BBC Micro unless you lived in the UK.

and X. That : key causes problems, meaning you'll need to remap your keys at some point.

›› Lastly, try to source disk images when possible. Tape files require several BASIC commands, and can take a long time to load. If you are using a tape image, load the file, and most software should work by entering these commands:

```
*TAPE
PAGE=&E00
CHAIN ""
```

4 BEEBEM

Windows users: Head to the website (http://www.mkw.me.uk/beebem), where there is a self-extracting EXE installer, which will create menu entries and desktop icons.

›› Linux users: Although a Linux port exists, it's very old, difficult to get running, and doesn't have all the features of the Windows original. However, the Windows version runs decently under Wine, so just use that.

›› BeebEm comes with a number of utilities and even a game disk, offering *Chuckie Egg*, *Dare Devil Dennis*, *Zalaga*, and *Cylon Attack*. Loading disks is easy. Simply open the main menu, choose "File → Run Disc," then select your disk image. BeebEm automates the loading process, entering BASIC commands for you.

›› Tapes are somewhat more difficult. From the main menu, you need to choose "File → Load Tape," and then open your tape image. At this point, however, nothing will happen—you need to enter the BASIC commands we gave above, and you should expect long loading times.

›› While BeebEm enables you to define your own keys ("Options → Define User Key Mapping"), you'll probably mess up one key by redefining another. If any keys aren't working, Horizon might be a better choice for that program.

5 HORIZON

Although there are only Windows and Mac versions of Horizon, worry not, Linux users. Where BeebEm runs decently under Wine, Horizon runs almost perfectly. Horizon doesn't come with an installer utility, so you'll need to download the zip file, then open the EXE file manually—you might want to make a desktop shortcut.

›› If you open the "Input" menu, there are predefined key remapping options. Unfortunately, loading programs is unintuitive in Horizon, and UEF tape images don't work (use BeebEm instead for those).

›› To load a disk image, open the main menu and choose "Drive: 0 → Auto Boot." Now run your disk by choosing "Drive: 0 → Insert Disk Image."

›› To load a tape image, first give it its own folder, and put the file there. Now load it by clicking "Tape: → Select Folder," then entering the BASIC commands given previously.

FIND SOFTWARE

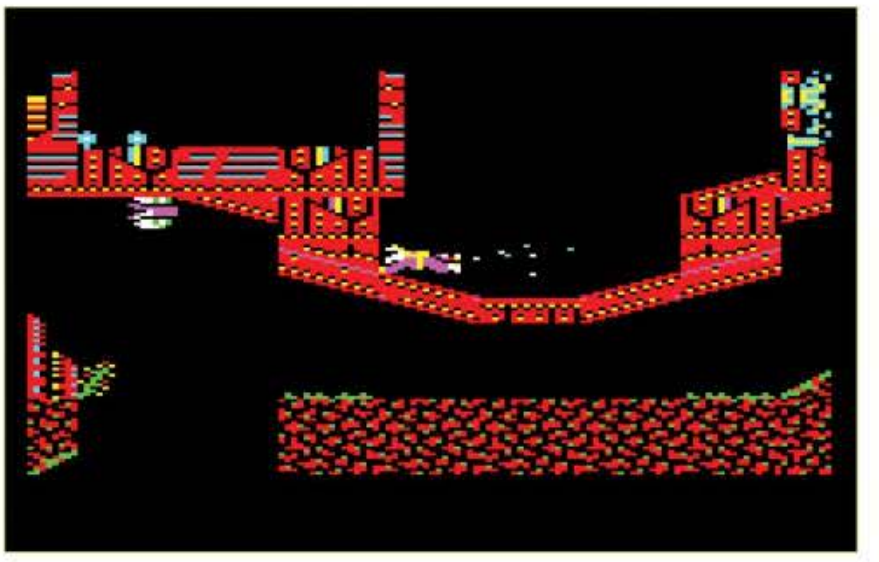
The list of commercial BBC Micro games isn't enormous, but that doesn't mean there aren't plenty of games. The Micro's real scene was in DIY coding, as was the BBC's intention, so the real gold is in program listings. Archive.org has magazines such as *BBC Micro User* and *The Micro User*, with listings to be typed out verbatim, enabling you to try out games and learn BASIC as you go.

As for commercial releases, fan archives exist aplenty, and are easily searched, but we can't advocate these for legal reasons. BBCMicro.co.uk is the most thorough and convenient (everything is on a simple disk image), but we doubt it has legal rights to do so. Something we can recommend, however, are the websites www.rucksackgames.co.uk and www.retrosoftware.co.uk, where you can get newly released software for the Micro, both commercial and freeware. Modern gaming highlights include *White Light* (2017), *Repton: The Lost Realms* (2010), and *Mountain Panic* (2013).

SPECIFICATIONS

BBC Micro (1981)

CPU:	MOS Technology 6502 @ 2MHz
RAM:	16/32KB
Launch price:	£235/$560 Model A, £335/$800 Model B
Graphics:	640x256, 8 colors
Sound:	Texas Instruments SN76489, four mono channels
Storage:	Cassette and 5.25-inch floppy
OS:	BBC BASIC
Released:	December 1981
Production:	1981–1994
Worldwide sales:	1.5 million



›› BBC games have a striking chunky aesthetic – expect a lot of red, yellow, green, and blue on black backgrounds.

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Make Multi-Page Docs in Affinity Publisher

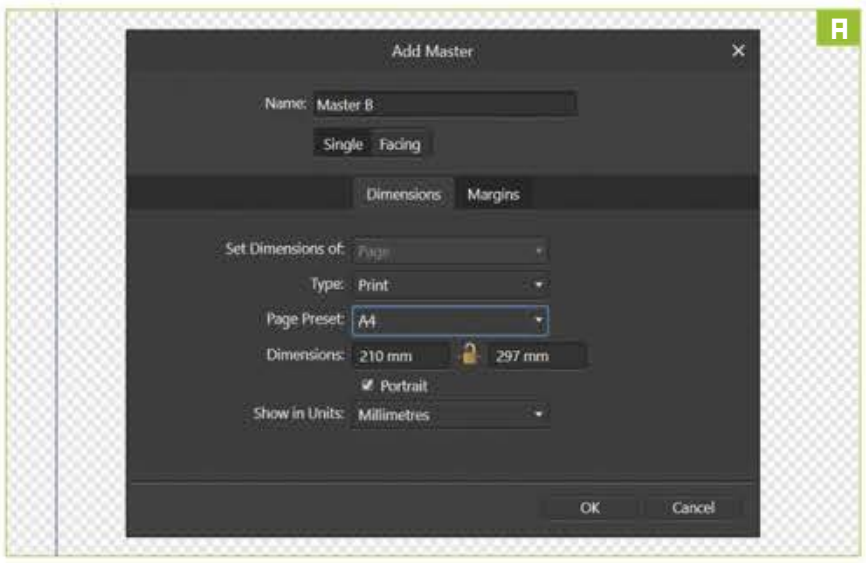
YOU'LL NEED THIS

AFFINITY PUBLISHER
See https://affinity.serif.com to find out more.

LAST MONTH WE CREATED a single-page document in Affinity Publisher, but Serif's app is capable of so much more. The creation of entire magazines, catalogs, and books in a single document is not outside of its capabilities.

This time we're looking at master pages, which enable you to replicate elements on every new page you create; text frame linking, which allows text to flow between pages; baseline grids, which enable you to lock your text in place and keep it lined up; as well as use of the Assets panel, which stores content you need frequently, but not regularly enough to place on a master page. There's a lot of depth to Publisher—we're not even touching on switching between Personas this month—and the app is well on its way to challenging InDesign and QuarkXPress at the top of the page layout (what used to be called desktop publishing) tree.

Once again, this is very much the way *Maximum PC* is produced, its ranks of highly paid graphic designers sweating under the lash of the art editor as they use Adobe InDesign on high-powered computers. **–IAN EVENDEN**



1 MASTER PAGES

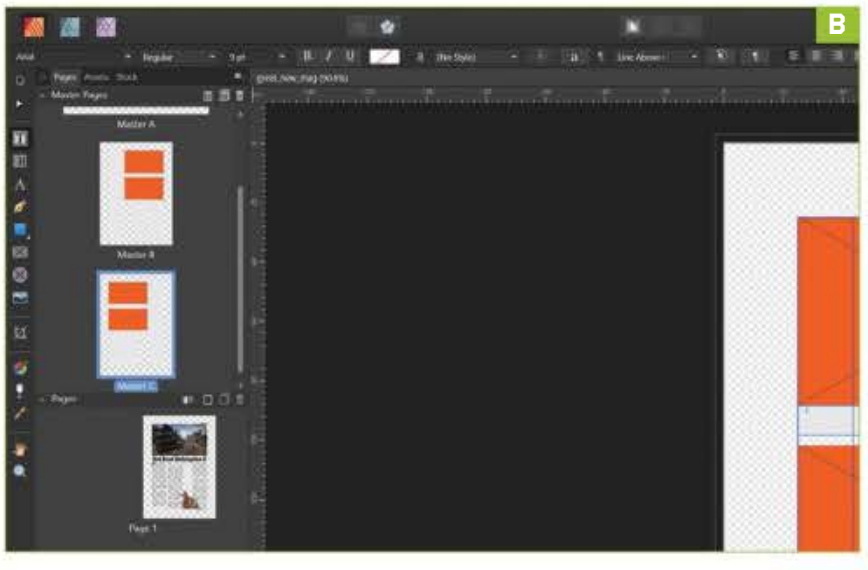
We touched on this last month, but if you're creating a multi-page document, you can save a great deal of time by setting up masters first, especially if you want your pages to be consistent. We set up a master page with a header and footer last month, but you can take this further by populating the master with all the empty frames you'll need to create a page, and by having multiple masters to create different styles of page, such as those balanced for appearing on the left or right of the publication. So, create a new document or open an existing one, and click "View → Studio → Pages" to open the Pages palette if it's not already open. By default, the master page at the top is a spread—two of the pages you specified when you created the document. This is fine if you want your spreads to all be the same, but if you want to mix it up, you can add single masters by clicking "Add Master" and choosing "Single." You can set different margins and even different page dimensions on the master, but as we want a consistent look, we'll keep them all the same [**Image A**].

2 POPULATE THE MASTER

If you've got an idea for a layout that will appear more than once in your document, that's a candidate for a master. On your newly created master page (probably called Master B), lay out your page as though it were a normal part of the document. Place frames for text and images, and place any logos or other graphics you know you'll want on every page. Remember to line things up using a grid of guides and columns as we did last month. We've got two 16:9 image frames (create a frame, then use the Transform palette to resize it to 16 x 9mm; drag one of its corner handles to resize it, but hold Shift to lock the aspect ratio), with text boxes under them to hold captions. Then there are three columns of text laid out across a seven-column grid, allowing a bit of white space. We're making two of these: one for a left-hand page, with the images on the left, and a mirror image version (Master C) for right-hand pages [**Image B**].

3 CREATE PAGES FROM MASTERS

Now, we can quickly create pages. The opening page of our document will be custom, with a header and large image, but the text will flow on to three subsequent pages. Create the new pages using "Add Pages" in the Pages palette, and they appear as a spread and one single page after our existing opener. To apply the masters, drag the one you want from the Master Pages palette to their targets on the Pages palette—we dragged Master C to pages 2 and 4, and Master B to page 3. From here, you can flow the text across pages using the blue arrow on the right of a full text frame, and insert images into the image frames as you want [**Image C**].



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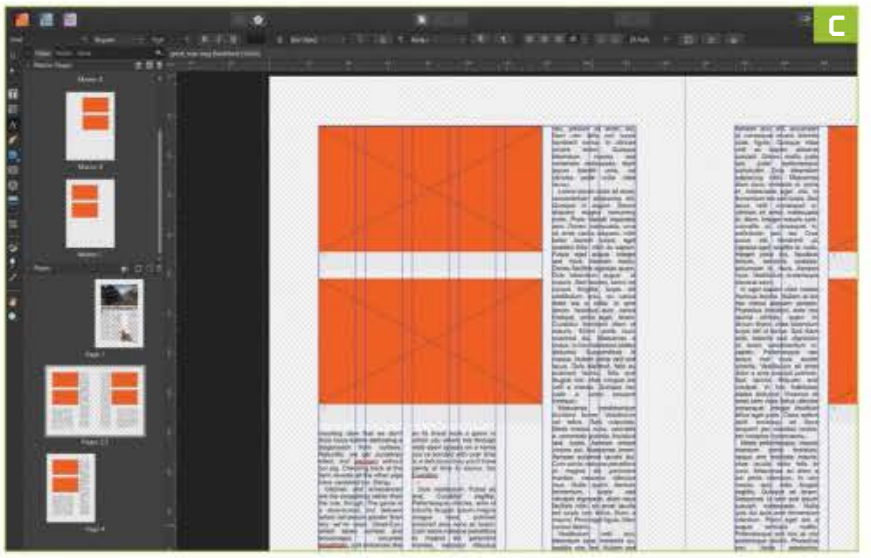


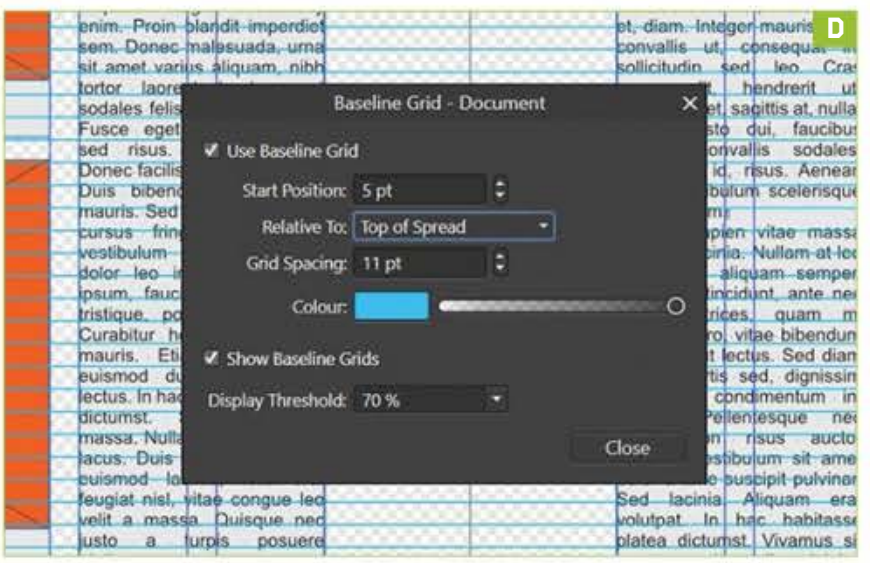
4 BASELINE GRID

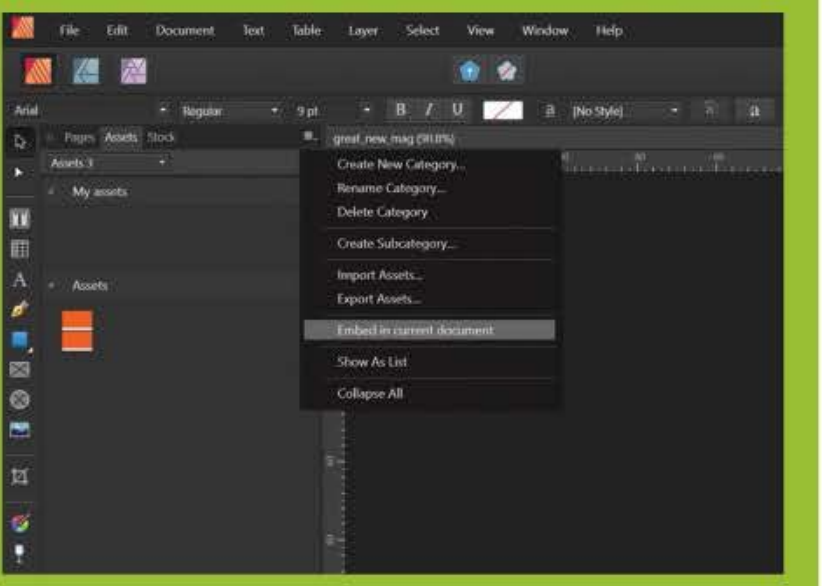
If you run your eyes horizontally across your columns now they're full of text (right-click one and select "Insert Filler Text" if you haven't got any), you may notice the lines don't line up. This is often fine in the world of newspapers, but considered messy in magazines, and can be fixed with a baseline grid—a series of horizontal lines your text can snap to. Open the Baseline Grid Manager using "View → Show Baseline Grid Manager" or using the button at the top of the interface that looks like a bunch of lines, and check the "Use Baseline Grid" box. The "Start Position" is an offset that moves the entire grid, so you can start it at the top of your columns. Before setting this, check the "Show Baseline Grids" box so you can see what you're doing. Now alter the "Start Position" so a grid line intersects perfectly with the top of one of your text columns. We generally set "Relative To" to "Top of Spread," and "Grid Spacing" to whatever the "Leading" setting is for your body text. (Leading is the gap between lines, so called because early printers used lead to separate lines; it's usually a little larger than your point size, so we're using 9pt text on 11pt leading.) In our experience using Quark, InDesign, and Publisher, locking to a baseline grid always messes something up, whether it's because you've got a drop cap (the large capital letter at the beginning of an article) or a crosshead (the larger lines used to separate sections of text) that's a different size to your body text. Generally, though, it's useful for making layouts neat, even if it does lead to lots of fiddling [**Image D**].

5 ASSETS PANEL

Similar to the Master Pages palette, in that it stores content for you to reuse, the Assets panel enables you to store a copy of a frame to reuse later. Whether it's a text frame with just the right number of formatted characters in it, or an image frame of the correct aspect ratio, it can save time because you don't need to recreate the asset from scratch. Open the Assets panel, which is in a tab next to Pages, and create a new Category by dropping down the panel's menu. Rename it if you want. Then, select the frames you want from your document, open the drop-down menu for the Category you created, and select "Add From Selection." Your frames appear in the Assets panel, and can be dragged back on to the document as many times as you need. Note that if your frames are from a master page, you need to go to the master page itself to add them to the Assets panel [**Image E**].

REFER TO MAXIMUM PC VOL. 25 NO. 2 PG. 68

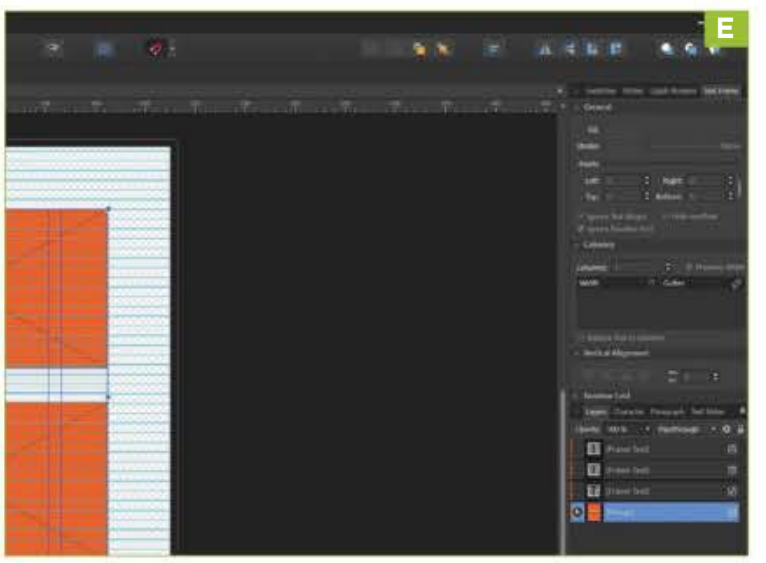




ASSETS ACROSS DOCUMENTS

Your Assets panel is saved on your PC and appears at the side of any document you open in Publisher, useful for transferring frames, but less so if you move computers—use "Embed In Current Document" from the Assets panel's drop-down menu if you want to take it with you.

To export your assets to send to someone else, gather them all together under a single "Category" heading. Drop down the panel's menu, and choose "Export." Give the file a name, and save it on a removable drive, ready to move to another PC. The assets file can get quite large if it has a lot of embedded images in it. To import on a different PC, open Publisher, open the Assets panel, drop down the menu, choose "Import Assets," navigate your way to your exported file, and hit "OK."



BUILD IT

ALAN DEXTER, EXECUTIVE EDITOR

Workstation Upgrade

Stretching the concept of an upgrade to ridiculous levels, we give a gaming PC a workstation makeover

LENGTH OF TIME: **3–4 HOURS**

LEVEL OF DIFFICULTY: **MEDIUM**

THE CONCEPT

We're doing things a little differently from normal this month. Instead of building a system from scratch, we're upgrading one of the office machines to better handle the multithreaded world in which we increasingly find ourselves. The machine in question is the test system I use on a daily basis, and while it has served me well for a couple of years, it is starting to show its age, and as we're surrounded by so much hardware, it feels like a good time to upgrade to something a bit more current. A bit more future-proof.

The starting point isn't a bad machine by any means: It features an Intel Core i7-7700K at its heart, along with 16GB of RAM, and a GeForce GTX 1080 graphics card. If there is a problem, it's on the storage side of things. The Samsung 840 SATA SSD is a little slow (particularly when it comes to write speeds), but at 250GB, the issue is more the fact that it's too cramped to install more than a few apps on, and I often find myself having to clear out junk in order to stop the drive filling up. This has forced me to turn to the big spinning hard drive more and more, which isn't exactly speedy.

Not everything needs to be thrown out in the upgrade. The Phanteks P400 case needs dusting, but other than that, it's a quality unit that will live on after the upgrade. The 3TB hard drive is also worth hanging on to, although upgrading to an M.2 NVMe drive should mean I'm not as reliant on it anyway. Finally, the PSU has plenty of capacity for a serious upgrade, and I'll be hoping to hang on to that as well. Everything else is up for grabs, though, which makes for quite the upgrade.

OFF THE CUTTING EDGE

THERE'S ONE DEFINING FACTOR when it comes to picking gear for this build: the intention to use hardware from the Maximum PC cupboard that won't be needed elsewhere. This pretty much crosses off anything that has just been released; and indeed favors gear that is no longer available. The sort of stuff you can pick up on special offer from online retailers, or eBay if you're brave enough.

The plan is to embrace the multithreaded landscape of all tomorrow's parties, so we start by grabbing a Threadripper CPU. The AMD Ryzen Threadripper 2970WX, to be exact. This last-gen chip may lack the raw bandwidth of Gen4 PCIe, but it still boasts an incredible 24 cores, or 48 threads, and offers the kind of power that was unheard of only a few years ago. Such CPUs are still widely available, and there are bargains to be had if you shop around.

The next obvious component is the motherboard, and here we turn to the Asus Prime X399-A, a solid option. We did need to upgrade its BIOS for it to support the second-gen Threadripper—something to bear in mind if you're looking to replicate such a build—but having first-gen chips to hand made this a straightforward task.

As for the graphics card, upgrading from a GeForce GTX 1080 is a big ask, but we happened to have a GeForce RTX 2080 that has been retired since the introduction of the Super rendition of the card, so this was a great opportunity to put the original 2080 to long-term use.

The rest of the components fell into place after this, with 32GB of colorful HyperX Predator RAM, a slightly aging 1TB Samsung 960 Pro M.2 drive, and Cooler Master's ML240P Mirage AIO CPU cooler representing the most up-to-date component in the machine. This was used mainly because we don't have a lot of TR4-compatible coolers available, but also because it's a really good cooler.

INGREDIENTS

PART		STREET PRICE
Case	Phanteks P400 (Glacial White) Tempered Glass Edition	$N/A
Motherboard	Asus Prime X399-A	$317
CPU	AMD Ryzen Threadripper 2970WX	$1,249
CPU Cooler	Cooler Master MasterLiquid ML240P Mirage	$160
Memory	32GB (4x 8GB) HyperX Predator RGB DDR4 2,933MHz	$233
GPU	Nvidia GeForce RTX 2080 Founders Edition	$799
PSU	BeQuiet Straight Power 11 850W	$N/A
SSD	Samsung 960 Pro M.2 1TB	$346
HDD	Western Digital 3TB Red	$N/A
OS	Windows 10 Home 64-bit	$N/A
Total		$3,104

1 OUT WITH THE OLD

WE START as we always do with any build—by stripping down the case to its bare skeleton. As this case houses a whole system already, this is slightly more convoluted than normal, but still isn't too tricky. We start by releasing the two thumbscrews that hold the retention bar over the expansion slots, and then unscrew the two thumbscrews holding the graphics card in place. Release the clip at the bottom of the card, disconnect the two power cables, and the card slides out with ease. We also remove the rear fan at this point, and set it aside for later.

2 CLEAR THE DECKS

NEXT WE SET ABOUT removing the old motherboard. We disconnect the power connectors, along with any other cables that are easy to unclip, before unscrewing the nine screws holding the motherboard in place (a magnetic screwdriver is your friend here), and easing the motherboard out gently, setting it to one side. The front panel of the Phanteks P400 case pops off easily, affording easier access to what's left inside. We initially left the two fans at the front of the case in place, but as you'll see, had to scrap that idea in the end, and we should have removed them from the start. The only thing left in the case at this stage should be the PSU.

3 IN WITH THE NEW

WITH THE CASE PREPARED, we can turn to the core of the new system. We start by installing the CPU in the Asus Prime X399-A. Threadripper motherboards have a slightly convoluted system for inserting the CPU, but the order you release and tighten the three Torx screws is clearly marked, and easy to follow. Once done, we install the M.2 drive by removing the chunky heatspreader toward the bottom of the motherboard, then screw the drive in place using the mounting peg and screw that can be found in the motherboard box. After this, we install the RAM sticks, and the core of the system is ready.

4 BUILT TO COOL

ALL-IN-ONE CPU COOLERS are great, especially when you're looking at something as powerful as Threadripper, but they're still a bit of a pain to set up for the first time. The ML240P Mirage is actually one of the easiest ones we've put together, at least. Simply attach the brackets either side of the CPU block (the right way around—align it with the motherboard to check the holes line up), screw them in place, and then attach the fans to the radiator. Be mindful of the fan cables as you do this, because they need to be able to stretch to the motherboard headers once everything is in place.

5 BIG INSTALLATION

IT'S NOW TIME to slide the motherboard into place. Don't forget to clip the I/O shield in position beforehand. The motherboard is loaded up with the CPU, SSD, and RAM at this stage, and is weighty, so be careful as you ease it in. Screw it down on to the offsets using the nine screws you removed earlier. The next step is to attach the AIO cooler. It's at this point we discovered there wasn't room to install the radiator in the roof of the case, so we removed the front fans in order to install it there instead. Fix the radiator in place using standard screws.

6 FINISHING FLOURISHES

SLIDE THE GEFORCE RTX 2080 INTO PLACE, and secure it with the thumbscrews before attaching the power cables—we couldn't thread these up from the bottom, because we couldn't get the clips through, so instead we routed these from the side instead. Speaking of which, you can now connect the rest of the cables—both power connectors and the case's front panel leads. This is a roomy case, and we didn't have too many problems here. The only issue we had was with the RGB lighting of the AIO cooler, but we wanted subtle lighting anyway, so didn't pursue this. We finish off by screwing in the old HDD and connecting its cables, and we're done.

1 **The tubes on all-in-one CPU coolers can be unwieldy beasts, and while we wanted them to come out of the top of the block here, we just couldn't get them to do so, and so settled with them coming out of the bottom.**

2 **We initially intended to place the radiator in the roof of the case, but the radiator block and fans were too large to fit above the motherboard, so we went for front mounting instead. If needed, we can always reinstall the front fans in the top.**

3 **There's no obvious place to mount hard drives in this case, other than at the front here, on top of this removable plate.**

A SERIOUS UPGRADE

BEFORE UPGRADING, this machine was fine for gaming, and could turn its hand to more serious work at a push. The aging storage was holding it back, though, and it did feel sluggish in even day-to-day tasks at times. After the upgrade (or complete rebuild, if we're honest), this machine is an absolute powerhouse—look at the Cinebench result below if you need proof (the zero-point results were taken from the machine before its upgrade). That storage overhaul means that it feels smooth and responsive across the board; no need to go and make coffee whenever a huge app or game is fired up.

The overall build went well, and there isn't much we'd change. Obviously, we're lucky having so much gear to hand—flashing the motherboard BIOS, for instance, just required slotting in a first-gen Threadripper, updating the BIOS, then swapping back to the second-gen chip. Something that took less than half an hour, as opposed to weeks getting a replacement motherboard.

There's still room to add extra fans, and we may fight the cabling to try to add a little color, but there's no need for this rig to be lit up like the Vegas strip to enjoy its thread-heavy power. The lighting from the mobo is subtle, and there's just enough light from the RAM and graphics card to see that it's all working OK when you hit the power button.

Returning to the performance, there was one anomaly when testing, and that was in *Total War: Warhammer II*—we saw a modest increase at 4K, as shown, but at lower resolutions, the frame rate was stuck in the mid-30s. We knew switching to Game Mode in Ryzen Master would improve this a little, but weren't expecting to hit almost three times the frame rate at 1080p compared to Creator Mode—it really does make that much difference in this one game. At 4K, the frame rate jumped up to 43fps, which is a notable improvement. The other games weren't affected anywhere near as much, just a frame or two at 4K. So, we'll stick with all the cores and threads of Creator Mode unless we spot sluggish behavior.

The upgrade from a GeForce GTX 1080 to an RTX 2080 hasn't blown us away. 3DMark Fire Strike may be a synthetic test, but it's a good indicator of power, and the 7 percent improvement of the RTX 2080 over the GTX 1080 speaks volumes. Gaming performance is improved, especially when the Threadripper is in Game Mode, but even here, it isn't enough for to us recommend such an upgrade. At least we can experience real-time ray tracing now, albeit not at 4K.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	946	4,279 (352%)
CrystalDisk QD32 Sequential Read (MB/s)	496	3,445 (595%)
CrystalDisk QD32 Sequential Write (MB/s)	196	2,111 (977%)
Rise of the Tomb Raider (fps)	51	65 (27%)
Total War: Warhammer II (fps)	32	36 (13%)
Tom Clancy's Ghost Recon Wildlands (fps)	31	37 (19%)
3DMark: Fire Strike (Index)	17,347	18,571 (7%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an Intel Core i7-7700K, 16GB (2x 8GB) of HyperX Savage DDR4 @ 3,000MT/s, an MSI GeForce GTX 1080 Gaming X, and a 250GB Samsung 840 SATA SSD. All tests were performed at 4K at the highest graphical profile.

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Maingear Element

A new gaming laptop enters the ring, and it can box all 10 rounds

WITH SO MANY BRANDS, such as Asus and MSI, dominating the gaming laptop landscape, it's exciting when an unfamiliar name comes along. Granted, Maingear isn't a no-name company—the boutique system builder has been around since 2002—but it's entering the notebook arena for the first time with its Element and Vector laptops.

The model tested here is the retail version of the Element, which is slim, sleek, and weighs barely over four pounds, with a bezel of just 0.25 inches. The tenkeyless keyboard also helps give the Element its slim dimensions. The keys themselves are very square and packed tight, leaving more room at the bottom for a larger than average touchpad—but they also respond quickly, thanks to the lightweight, optical silent switches. For "silent" switches, though, they are surprisingly loud and clicky.

Also, it took this reviewer a while to adapt to the compressed keyboard layout, being used to the spaced-out keys of something like the Lenovo Legion Y740. Several hours of typing on the Element were required to get accustomed to the keyboard, and it might be a little too compact for anyone with large hands.

Specs-wise, the Element comes with a ninth-gen Intel Core i7-9750H processor, an Nvidia GeForce RTX 2070 Max-Q graphics card, 32GB of DDR4-2666 RAM, and, while many other high-end gaming laptops opt for less than 1TB of primary SSD storage (usually with a secondary HDD), the Element has a 2TB NVMe SSD. This model also features Wi-Fi 6, one Thunderbolt 3/USB Type C port, three USB 3.1 Gen 2 ports, an HDMI 2.0 port, a current-standard Ethernet port, separate mic and audio jacks, and an SD drive—plus a glass touchpad. It checks all the boxes and then some.

Given the total list of specifications, it's not surprising that the Element is priced at $2,300, which is in line with competing notebooks. It would be more competitive if it ditched the Max-Q graphics card, but that would come at the expense of the notebook's slim, compact design. Switching over from balanced to redline gaming mode only gave each game a 5fps boost—and spun the fans so fast the Element could have been the first laptop to achieve flight. That small boost isn't worth potentially wearing out the fans faster or overheating the system, but even while pushing each game to its max, the laptop stayed reasonably cool.

On ultra graphics, *Division 2* cranked out 65fps, *Metro Exodus* hit 46fps (ray tracing off), and *Total War: Warhammer II* managed between 67fps and 75fps. Comparing other benchmarks to another of our reviews, MSI's GS75 Stealth, the synthetic benchmarks are not terribly different. The GS75 scored 15,873 in 3DMark Fire Strike, while Maingear's Element scored 15,344—completely in line with what you'd expect when comparing the RTX 2070 Max-Q to the RTX 2080 Max-Q. While this notebook is capable of handling demanding games, it comes at a slight cost to the frame rate. Dropping the graphics quality to high or medium pushes *Metro Exodus* into the 60fps range, for instance.

As for the battery life, the Element has many other laptops beat when it comes to normal productivity and streaming video. At just over eight hours of life, you won't need to plug this laptop in until the end of the workday. When it comes to gaming, though, the Element lasted just over two hours—enough time for a few quick matches in *Overwatch.*

Put the Element next to the usual names from the best gaming laptop lists, and you've got something just as well designed, reliable, and competitively priced. It checks all the boxes one would expect from a gaming laptop of this caliber. We've been impressed by the quality of Maingear's desktops in the past, and can now say the same thing about one of its laptops. If you prefer your laptops small, light, and thin, give this one more than a passing glance. **–JOANNA NELIUS**

VERDICT

8

Maingear Element

ELEMENTAL Sleek design; competitively priced; runs decently cool.

MENTAL Max-Q graphics card; loud fans; no 1440p or 4K option.

$2,300, www.maingear.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,030	1,172 (14%)
CrystalDisk QD32 Sequential Read (MB/s)	3,374	1,676 (-50%)
CrystalDisk QD32 Sequential Write (MB/s)	2,530	1,926 (-24%)
3DMark: Fire Strike (Index)	13,610	15,515 (14%)
Rise of the Tomb Raider (fps)	92	96 (4%)
Total War: Warhammer II (fps)	62	72 (16%)
Tom Clancy's Ghost Recon: Wildlands (fps)	49	50 (2%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our gaming laptop zero-point is the Acer Predator Triton 500, with an Intel Core i7-8750H, Nvidia GeForce RTX 2060 Max-Q, and 16GB of DDR4-2666. All games tested at 1080p at the highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i7-9750H
Graphics	Nvidia GeForce RTX 2070 Max-Q
RAM	32GB DDR4-2666
Screen	15.6-inch 1080p IPS 144Hz
Storage	Intel 2TB NVMe SSD
Ports	2x USB 3.1 (Gen 1) Type A, 1x USB 3.1 (Gen 2) Type A, 1x USB 3.1 (Gen 2) Type C/ Thunderbolt 3, HDMI 2.0, mic-in, headphone-out
Connectivity	Intel Wi-Fi 6 AX 200, Bluetooth 5.0, Gigabit Ethernet
Weight	4.1lb
Size	0.8 x 9.2 x 14.0 inches

Compact and sleek.

AMD Radeon RX 5500 XT 8GB

Is extra memory worth the added cost?

AMD'S RETAIL Radeon RX 5500 XT series of graphics cards is here, bringing additional options to the budget and mid-range market. AMD's Navi architecture hasn't changed, although Navi 14 does cut the potential number of compute units from a maximum of 40 down to a maximum of 24—with the 5500 XT enabling 22 of those CUs. There are two versions of the 5500XT; the only difference is the VRAM and a $30 increase in price.

The 5500 XT 4GB card matches up against the GTX 1650 Super, and the two are effectively tied in performance. The 8GB card, meanwhile, has to take on the GTX 1660, and Nvidia's card has the same number of GPU cores: 1,408. The problem for AMD is that Nvidia's GPU cores tend to perform a bit better overall. At least the TDP is about the same—120W versus 130W won't matter either way.

There's little difference in features to speak of. Technically, Nvidia's GTX 1660 can enable ray tracing in games that support it. In practice, the 1660 isn't fast enough to make ray tracing worthwhile. There are other facets of performance, but overall the two sides are evenly matched in the mid and lower markets.

There's also a jump in generational pricing, especially with current prices. The RX 590 launched at $279; today, you can get that same card for $179. It uses more power, but performance is going to be very similar to the RX 5500 XT 8GB. Which brings us to the real question: How does the RX 5500 XT 8GB perform?

At 1080p medium, there's no real benefit to the 8GB RX 5500 XT compared to the 4GB model. The RX 5500 XT is also tied with the GTX 1650 Super in overall performance, but the GTX 1660 is about 5 percent faster. Running medium quality at 1080p isn't really the goal if you're going to pay extra for the 8GB card, however.

Stepping up to 1080p ultra starts to favor the 8GB model over its sibling, though it's only a 7 percent improvement on average. The difficulty AMD faces is that at 1080p, even at maxed-out quality, there isn't a ton of games that truly need more VRAM. And of the games that do, none of them seems to need more than 6GB. That means, once again, that the GTX 1660 costs as much as the 5500 XT 8GB, but performs about 5 percent better.

At 1440p ultra, the 5500 XT 8GB shows its largest lead yet relative to the 4GB card. It's now 12 percent faster, but we're also looking at average performance across the test suite of 45fps. Every game still stays above 30fps, which means performance is generally better than current consoles. Lighter esports games, such as *CS:GO* and *Overwatch*, should be viable at 1440p.

As a general rule, we advise people not to skimp on VRAM. Yes, it costs more for the higher VRAM models, and performance doesn't always improve a lot with the extra memory. Except when it does, and then you could end up very disappointed that you cheaped out on your graphics card, and now have to turn down some settings. The RX 5500 XT 8GB is a continuation of that recommendation; you can save $30 by purchasing the 4GB model, but long-term, we don't think that's the best plan.

Ultimately, AMD's Radeon RX 5500 XT series is a reasonable offering. It's not clearly superior to other options, but it's also not clearly worse. If you're looking to buy a new graphics card, whether as an upgrade to an existing PC or as part of a new gaming build, it's worth a look. Performance of the 5500 XT 8GB is basically equal to the outgoing RX 590, while using about 100W less power. But if you're not set on AMD, look to the GTX 1660 or 1660 Super. **–JARRED WALTON**

BENCHMARKS

	AMD Radeon RX 5500 XT 8GB	Nvidia GeForce GTX 1660 Super
Tom Clancy's The Division 2 (Avg fps)	61/40	**70/45**
Assassin's Creed Odyssey (Avg fps)	45/35	**53/42**
Far Cry 5 (Avg fps)	83/57	**95/65**
Shadow of the Tomb Raider (Avg fps)	70/46	**85/56**
Middle Earth: Shadow of War (Avg fps)	58/39	**81/54**
Metro Exodus (Avg fps)	46/36	**53/40**
Total War: Warhammer II (Avg fps)	54/40	**71/54**

Best scores are in bold. Our test bed consists of an Intel Core i7-8700K, 16GB of G.Skill DDR4-3200, an MSI MEG Z390 Godlike, and a 1TB Samsung 970 Evo M.2 SSD. All games are tested at their highest graphical profile with AA turned on, at 1080p and 1440p respectively.

VERDICT **8**

AMD Radeon RX 5500 XT 8GB

MEMORABLE Solid 1080p performance; efficient Navi architecture; plenty of VRAM.

FORGETTABLE Slower than GTX 1660; higher generational pricing.

$200, http://amd.com

SPECIFICATIONS

GPU	Navi 14
Lithography	7nm
Transistor Count	6.4 billion
GPU Cores	1,408
Texture Units	88
ROPs	32
Core/Boost Clock	1,670/1,845MHz
Memory Capacity & Type	8GB GDDR6
Memory Speed	14GT/s
Memory Bus	128-bit
TDP	130
Display Connectors	DisplayPort 1.4, HDMI 2.0

The 5500 XT comes in twin-fan and triple-fan configurations.

The Pro X looks fantastic, but can't keep up on the performance side.

Microsoft Surface Pro X

X is not gonna give it to ya

LOOK, WE WERE REALLY excited about this one. The Surface Pro series has long offered some of the best tablets in the biz, their detachable keyboards providing a sleeker experience than most two-in-one convertible laptops. While the Surface Pro 7 delivered high-quality performance across all areas, thanks to its 10th-gen Intel Core CPU, its chassis was familiar, all hard silver edges and chunky bezels. The Pro X looked like the breath of fresh air that the Surface really needed: a total redesign of the exterior and peripherals, coupled with a custom-built processor using a hybrid of Microsoft and Qualcomm's technology.

It should have been awesome. Yes, we knew the ultrathin new design was going to cause a hit to computing performance, and the lack of Intel's Iris Plus integrated graphics was a shame, but the Pro 7 and Pro X appeal to somewhat different target audiences anyway. The Pro 7 is a bulkier, more powerful machine, while the Pro X was clearly designed for the consumer who absolutely must have the best-looking tablet on the morning commute.

But there's a glaring problem with the Pro X, an elephant in the room that Microsoft seems uncomfortable to address. The Microsoft SQ1 processor that powers this hybrid tablet is the first of its kind, a 3GHz ARM-based chip with integrated graphics. Unfortunately, that means we're looking at an ARM-based OS running adapted versions of Windows 10 and Microsoft Office.

If you're not familiar with ARM-based systems, allow us to give you a quick breakdown of the benefits; in other words, why Microsoft chose to utilize one for the Pro X. In theory, ARM processors are cheaper, more power efficient, and faster, although that last one comes with a caveat: ARM chips perform one task at a time to speed things up, which can cause issues if you want to multitask. These chips are most commonly found in mobile devices such as smartphones, Android tablets, and handheld games consoles.

So, here's the problem: The SQ1 can't run 64-bit software. That means no Photoshop (or any of Adobe's Creative Cloud suite), no AutoCAD, and very few benchmarks for us. We weren't able to get any games running on it at all—a stark contrast to the surprisingly good casual gaming performance that the Pro 7 offers. While you'll note that we did manage to get a figure out of 3DMark's Fire Strike benchmark, be aware that the tablet crashed twice before successfully completing the test.

A small handful of ARM-enabled software is good to use, and the Pro X can run older 32-bit programs via a hidden emulator, but even that turns out to be a bit wonky. The 32-bit version of Chrome was noticeably slower than Edge, despite the Pro X model we reviewed having plenty of memory.

If you think you can get along fine with 32-bit software, that should be fine. In theory. The benefits of the ARM platform could outweigh the compatibility issues, but unfortunately they just don't. The Pro X doesn't feel remotely faster than the Pro 7, and the supposedly "all-day" battery life is weak, failing to cap 10 hours even with reduced brightness. The only notable benefit is the SQ1 chip's built-in LTE connectivity, which allows you to plug in a SIM for some 4G wireless. The lack of a headphone jack truly sucks, though.

The external hardware is undeniably impressive. The Pro X sports a sleeker new chassis, only available in black, with a much smaller bezel than the previous Surface models. The screen within that bezel is bright, colorful, and responsive to touch control. The detachable keyboard cover and Surface Pen have also had a facelift, with the new Slim Pen snapping magnetically into a wireless charging dock on the keyboard. As such, they now come as a unit, although the pair will set you back $270.

Pricing on the Surface Pro X is similarly harsh, with the cheapest model costing $999. Our review model uses 16GB of RAM alongside a 256GB SSD—not much storage for the high price of $1,499. When the performance struggles to match that of laptops worth less than $500, the rest of the price is feasibly supposed to make up the ultralight design, but ultimately? It's not worth it, and frankly, we're disappointed. **–CHRISTIAN GUYTON**

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	561	DNF
CrystalDisk QD32 Sequential Read (MB/s)	3,100	938 (-70%)
CrystalDisk QD32 Sequential Write (MB/s)	557	723 (30%)
3DMark: Fire Strike (Index)	1,062	773 (-27%)
Rise of the Tomb Raider (fps)	5	DNF
PCMark 8 (Index)	2,543	DNF
Battery Life: Movie Playback (Mins)	840	547 (-35%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our notebook zero-point is the HP Spectre X360, with an Intel Core i7-8565U, integrated Intel UHD Graphics 620, and 8GB of DDR4-2400. *Rise of the Tomb Raider* is tested at 1080p at the highest graphical profile.

VERDICT **5**

Microsoft Surface Pro X

PROFESSOR X Excellent exterior design; great peripherals; LTE is good.

X RATED Significant compatibility issues; no headphone jack; unimpressive battery.

$1,499, www.microsoft.com

SPECIFICATIONS

Processor	Microsoft SQ1
Graphics	SQ1 Adreno 685 GPU
RAM	16GB LPDDR4x
Screen	13-inch PixelSense (2880x1920)
Storage	256GB NVMe SSD
Keyboard	Detachable island-style backlit with Slim Pen
Ports	2x USB-C, 1x Surface Connect port, Surface Keyboard connector port, 1x nano SIM
Connectivity	Wi-Fi 5 802.11ac, Bluetooth 5.0, Qualcomm X24 LTE
Weight	1.7lb
OS	Windows 10 Home

Razer Blade 15 Studio Edition

It's time to get creative

THE RAZER BLADE LAPTOPS are all pretty darn sweet-looking machines. Sleek black laptops with perfectly designed keyboards and tiny screen bezels, and powerful internal hardware to boot. The Blade 15's new Studio Edition is no exception: a ninth-gen Intel Core i7 processor along with a Quadro RTX 5000 GPU, crammed into an impressively slender chassis, carved from a single block of aluminum. This laptop ditches the usual black-and-green aesthetics of the Blade series, though, instead opting for a more professional silver finish.

This Blade feels like a staging ground for turning a great gaming laptop into a great content-creation laptop. A high-end graphics card and fully addressable RGB-lit keyboard can still scratch the gamer itch, while plenty of RAM and a large 4K touch display mean that this laptop is well situated to handle video editing and graphic design tasks.

Our review model of the Blade 15 Studio Edition comes with a 15.6-inch 4K display at a 60Hz refresh rate. That refresh rate might be rather unexciting, but this OLED panel brings high brightness and dazzlingly good color that looks great even in well-lit environments. Touch control is a nice bonus for creatives who enjoy quick fingertip navigation, although the potential for fingerprint-related troubles is high, and the Blade 15 SE doesn't come with a stylus of any sort to avoid such woes.

Physical connectivity is a winning aspect here—three standard USB ports are joined by a Thunderbolt 3-enabled USB-C port, Thunderbolt 2 port, and an HDMI port, perfect for connecting extra monitors for workstation tasks. Using the Blade 15 SE as a desktop replacement is definitely viable, as high-powered laptops like this typically chew through battery. However, the battery life is impressive for a workstation laptop; around four to five hours of use, depending on software and brightness. The lack of Gigabit Ethernet is a shame, but not a deal-breaker.

The main downside of the Blade 15 SE isn't the battery or ports, then, but the lack of a Core i9 CPU. The i7-9750H at the heart of this is perfectly competent, but it's not exactly groundbreaking, and it weakens the potential of this system for CPU-intensive tasks. This laptop already has an upsetting price point; Razer could have sprung for a superior CPU.

In fairness, this system is focused on creativity, not number-crunching. The rest of the internal components do the job; a high-speed 1TB SSD and 32GB of memory are good to see, with that Nvidia Quadro GPU pulling its weight in a big way. All that hardware generates a lot of heat, though, and the Blade 15 SE's twin fans clearly struggle to deal with it. The laptop gets uncomfortably hot after extended use, even with adequate clearance underneath it for airflow.

The external design is, of course, stunning. The trackpad is large, central, and easy to use, and that keyboard isn't just illuminated by customizable RGB effects—it's very satisfying under your fingertips, with nice large keys and reasonable travel for such a slim laptop. It actually looks a little small at first glance, but that's just because of this 15-inch machine's large form factor and flanking speakers, which can pump out music at an impressive volume.

Lastly, we must bring ourselves to address that most divisive of subjects: pricing. The Blade 15 SE costs a tidy 4,000 dollars. Yes, it's expensive, but the high-end studio GPU and cutting-edge design mean that it's certainly not bad value for money. Cheaper versions are available, too, if you're willing to dial it back with the GPU—a GTX 1660 Ti model with a 1080p screen is only $1,600, which is a far more reasonable prospect. Ultimately, the Blade 15 Studio Edition is pretty awesome; pricey, sure, but still awesome. Now, if you'll excuse us, we've got to make some phone calls to Razer PR to explain why we deserve to keep it. **–CHRISTIAN GUYTON**

VERDICT

9

Razer Blade 15 Studio Edition

SHARP Awesome screen; great chassis design; very solid performance.

BLUNT Runs hot; expensive; CPU is a little limited.

$4,000, http://razer.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,030	814 (-21%)
CrystalDisk QD32 Sequential Read (MB/s)	3,374	3,241 (-4%)
CrystalDisk QD32 Sequential Write (MB/s)	2,530	2,977 (18%)
3DMark: Fire Strike (Index)	13,610	15,831 (16%)
Rise of the Tomb Raider (fps)	92	107 (16%)
Total War: Warhammer II (fps)	62	78 (26%)
Tom Clancy's Ghost Recon: Wildlands (fps)	49	58 (18%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Best scores are in bold. Our gaming laptop zero-point is the Acer Predator Triton 500, with an Intel Core i7-8750H, Nvidia GeForce RTX 2060 Max-Q, and 16GB of DDR4-2666. All games tested at 1080p at the highest graphical profile.

SPECIFICATIONS

CPU	Intel Core i7-9750H
Graphics	Nvidia Quadro RTX 5000 16GB
RAM	32GB DDR4-2667
Screen	15.6-inch OLED 4K touchscreen @ 60Hz, 100 percent DCI-P3
Storage	1TB M.2 NVMe SSD
Ports	1x HDMI, 3x USB 3.2 Gen 2 Type-A, 1x USB 3.2 Gen 2 Type-C with Thunderbolt 3, 1x Thunderbolt 2, 1x SD card reader, RJ-45, 3.5mm headphone jack
Connectivity	Wi-Fi 6, Bluetooth 5.0
Weight	4.88lb
Size	0.7 x 9.6 x 14.0 inches

The Blade 15 is big and powerful, but it's not as heavy as you might expect.

BenQ DesignVue PD3220U

Made for Mac, nearly perfect for PC

SHOP CAREFULLY and you can pick up a 4K monitor for under $200; $300 will bag you a 32-inch 4K monitor with a decent VA panel. Which begs the question: Why would you unload nearly $1,200 on this?

It has a 31.5-inch (read 32-inch) panel, 4K resolution, and tops out at 60Hz. So far, so samey compared to that $300 option. However, the DesignVue PD3220U ups the ante with IPS rather than VA panel tech. That implies better color accuracy, viewing angles, and response, but inferior contrast compared to a VA panel.

Problem is, $600 will buy you a 4K 32-incher with an IPS panel. As it happens, BenQ itself will sell you such a screen. So, what justifies the 100 percent price premium? It's not high refresh, that's for sure, what with the PD3220U pegged at 60Hz. Nor is gaming generally the remit here, even though this monitor will turn its hand to more frivolous pursuits if you have the requisite beefy GPU to drive it.

Instead, productivity and style are the recipe here. The latter involves symmetrically slim bezels on all four sides, plus a slick stand in what Apple, were it the manufacturer, would doubtless denote as Space Gray, and which offers a full range of articulation, including rotation to portrait mode. Indeed, Apple's MacBook Pros are a large chunk of the stated target market for the PD3220U, hence the sympathetic styling.

The Apple-centric execution is more than just skin deep—BenQ has also fitted the PD3220U with dual MacBook-friendly Thunderbolt 3 ports. Both allow for single-cable connectivity carrying the display signal, USB connectivity, and charging, although one port supports 85W of charging power, the other just 15W. Anyway, the point is that this is an ideal display for a single-cable setup using a powerful laptop computer, be it an Apple computer or a portable PC.

It's also worth noting that the full Thunderbolt 3, as opposed to merely USB Type-C, spec of those dual ports means you can daisy-chain a secondary monitor and thus drive two displays with a single cable. Nifty. While we're on the subject of connectivity, a KVM switch and a hotkey puck for quick switching between display modes add yet another layer of utility to what was already a very flexible display.

Rounding out the significant specs is support for HDR10 content. BenQ is careful to not claim full HDR display capability, which is welcome, given this monitor is limited to 300cd/m^2 brightness and does not offer local dimming. However, the HDR10 signal processing means that colors can be seen correctly, allowing this monitor to be used for HDR content creation, a significant boon for content pros, who'll also be interested to learn that the PD3220U is claimed to be good for 100 percent of the sRGB color space and 95 percent of DCI-P3.

Bearing all of that in mind, in action, the PD3220U is as good as you'd hope. The colors and clarity are fabulous, and the viewing angles utterly impeccable. Moreover, 4K at 32 inches provides a very nice compromise between a tight pixel pitch and usability at 100 percent scaling, if the latter is a preference. This is an impressively precise display solution.

The BenQ PD3220U is therefore a very slick all-around option for content professionals or serious desktop PC enthusiasts. In fact, pretty much anyone other than gamers would be very happy to have it as a primary display. Whether it's worth the extra money over a less well-featured 32-inch 4K IPS monitor really depends on the premium you place on flexibility and connectivity. If that stuff matters, the PD3220U will be worth the extra money. **–JEREMY LAIRD**

VERDICT 8

BenQ DesignVue PD3220U

+ OSCAR-WORTHY Fabulous IPS panel; fantastic connectivity.

– NOT NOMINATED Pretty pricey; only 60Hz refresh.

$1,199, www.benq.com/en-us

SPECIFICATIONS

Panel Size	31.5-inch
Panel Type	IPS
Resolution	3840x2160
Brightness	300cd/m^2
Contrast	1,000:1
Pixel Response	5ms
Refresh Rate	60Hz
VESA	100x100mm
Inputs	DisplayPort, 2x HDMI, 2x USB-C with Thunderbolt 3

BenQ's new 4K monitor offers fantastic connectivity and image quality.

Beyerdynamic Fox

A USB desktop mic to rival its contemporaries in the studio

AS A RULE OF THUMB, taking the leap from your headset mic to a dedicated desktop microphone always sounds noticeably better. With larger diaphragms and sturdier outer casing, dedicated mics can capture low-end frequencies, in particular, much more accurately than the tinny old electret condenser through which you've been shouting at campers and breathing Cheeto dust for your gaming headset's lifespan.

But not all desktop microphones are born equal. In fact, this is something of a growth sector for gaming peripheral manufacturers and established pro audio brands alike—until a few years ago, we were all pretty much satisfied with sounding like a taxicab dispatcher on voice chat, but Twitch changed the landscape. Now, not only are microphones such as the venerable Blue Yeti capable of incredible spoken-word fidelity levels, but they're getting competition from the likes of Audio-Technica and Beyerdynamic, too, who bring decades of studio expertise to the party. And hoo boy, is that ever apparent with this excellent Fox USB mic.

SOUND BITES

Starting with the basics, the Fox is a cardioid condenser and doesn't feature any other polar patterns, unlike a lot of its rivals on the market. Available now for $150, it includes a very sturdy pop shield, a bright orange braided 1m USB cable, a 1/4-inch to 5/8-inch adapter, and a reassuringly heavy desktop mount. As with any microphone you intend to use while you're sitting at a computer, it's best deployed using a boom arm, to keep it high up and away from your noisy keyboard and all the accidental knocks it's sure to pick up when sitting on your desktop. The adapter's definitely welcome, then, but it's worth noting that as desktop mounts go, this one's pretty serviceable. You can adjust the angle to point the front of the mic up toward your mouth, without fear of it tipping over or changing position mid-stream, and we found it blocked out the sounds of our banging into the desk quite well. If it's placed nearer to your keyboard than your mouth, though, it's always going to pick up some of that mechanical switch chatter.

The mic unit itself is built to a very high standard and features an all-metal construction around the shell—it really wouldn't look out of place in a recording studio, next to units ten times the price. The controls on the front are a less impressive plastic, and they do wobble just a little when you use them, but not so much that it becomes a problem. A mic mute, direct monitoring/PC audio mix, headphone monitoring volume, and headphone input make up the front, while a lone USB-C cable input can be found at the back.

The sound is magnificent—warm, well rounded, and with a slight dip in the higher frequencies (6–10K), which really smooths out vocals. While this array is obviously intended for straightforward vocal capture in a streaming setting, the Fox has the chops for much more. It can record 24-bit, 96KHz audio—better than CD-quality, for the audiophile casuals—and the overall shape of the sound is just as suited to mic-ing up a guitar cabinet, acoustic guitar, or melodic vocal performance as a Twitch broadcast. And for $150, that's really saying something. There are practical limitations here, though, if you do decide to go Quincy Jones on the Fox, principally the 1m USB cable. Being tethered within a one-meter radius of your PC is tricky, and really you'd need to buy a longer cable to make a musical recording situation happen.

The fact we're even talking about it like it's a possibility says so much about how far USB desktop mics have come. And it says a lot in particular about this debut USB mic from Beyerdynamic—with a little more investment in a boom arm and a longer cable, it's all your recording desires in one mic. **–PHIL IWANIUK**

VERDICT 9

Beyerdynamic Fox

+ FANTASTIC MR. FOX Solidly built; sounds like a studio mic; suitable for instrument recording.

– FARMER BOGGIS Short USB cable.

$150, https://global.beyerdynamic.com

SPECIFICATIONS

Frequency Response	20Hz–20KHz
Sample/Bitrate	24-bit/96KHz
Cable Length	1 metre
Polar Pattern	Cardioid
Element	Condenser
Power Consumption	0.5mA max

Roccat Kain 202 AIMO

Wireless wonder

OH, TO BE A FLY ON THE WALL in the meeting room where this mouse was first pitched. What does a mouse do—some disruptive but well-liked marketing wunderkind asks—if not just point and click? What if we just focused really hard on that part? What if—at this point, the marketing guy sweeps his hands around dramatically—we created the perfect click?

This scenario is, of course, fantastical. But the Roccat website claims that the Kain did take two years of brainstorming, redesigns, and rigorous testing, and then goes on to refer to it as "our masterpiece." Well, Roccat, we'll be the judge of that.

The Kain 202 AIMO, itself a minor evolution of the Kain 200, is the physical embodiment of this reviewer's favorite Ron Swanson quote: "Never half-ass two things. Whole-ass one thing." The Kain 202 isn't complicated, and it doesn't present itself as such. This isn't a mouse for people who like lots of buttons, flashy RGB lighting, or unbelievably high DPIs. It does one thing perfectly: clicking stuff.

The Roccat Owl-Eye sensor was designed in collaboration with PixArt, so the general sensitivity is great. The DPI clocks in at 16,000, exactly what you'd expect from a high-quality gaming mouse, as is the 1,000Hz polling rate. But the true worth of the Kain 202 isn't measurable in simple statistics, you see. It's more of a sensation; using the Kain simply feels good.

The exterior coating is comfortable, with a white matte finish that is dirt-resistant and feels comfortable under the palm, even after extended use. There's no thumb rest, but that's hardly a huge problem. The surface material is grippy, ensuring that it stays firmly under your hand, even during the sweatiest online matches, and the whole unit feels robust. We didn't throw ours at a wall in a fit of gamer rage, but we reckon that if we did, the 202 could shrug it off.

Of course, the buttons are what really matter here. Roccat wasn't messing around when it came up with the "Titan Click" split button design used by the Kain series, where low-tolerance springs and optimized switch positioning make for a clicking function that is responsive and sturdy, rated by the manufacturer for 50 million clicks. The Kain's firmware also claims to process clicks up to 16ms faster than other gaming mice, and in practice, it feels latency-free—impressive, given its wireless design.

Our favorite part, though, is the scroll wheel. Again, there are no bells and whistles here; no adjustable scroll speed or wheel lock, just a rubber-topped wheel that rotates and clicks with satisfying weight. The same can't quite be said of the two side-mounted buttons, which are fine, but lack the heft of the other buttons. That's it, though: This mouse doesn't have lots of programmable buttons, so if you're a strategy or MMORPG gamer, you may want to look elsewhere.

Setup is a breeze, simply requiring you to plug in the wireless USB dongle and power the mouse on. Roccat's Swarm software provides a degree of customization without ever getting in the way; there's a little rubber DPI tweaking button just behind the scroll wheel, which enables you to swap through up to five adjustable sensitivity levels. You can also adjust the brightness of the RGB-lit logo, although that remains hidden under the palm when in use. The battery life is solid, requiring a charge via USB cable roughly once every 40 hours (depending on usage).

Plugging the Kain in to charge does reveal one potential annoyance: The micro-USB port on the front of the mouse has a shaped plastic surrounding that effectively prevents the use of any third-party cable, meaning that if you lose the included cable, you're in trouble. Roccat doesn't even seem to sell the cables separately. Also in the box is a small USB adapter, but it doesn't appear to serve any real purpose unless you have a second identical cable, which again, you can't buy separately. It's weird.

It's only a minor issue, though. The lack of a storage space within the mouse chassis for the USB dongle is more irritating, limiting the portability of the mouse for laptop use (unless you're willing to risk losing the tiny dongle). But if you just want a high-quality wireless mouse for home use, the Kain 202 AIMO is almost perfect. –CHRISTIAN GUYTON

VERDICT **8**

Roccat Kain 202 AIMO

KAIN Excellent button response; quick and easy setup; good battery life.

ABEL Relatively feature-light for a gaming mouse; no slot for USB dongle; shaped micro-USB port really sucks.

$100, http://roccat.org

SPECIFICATIONS

Sensor	Optical
Sensitivity	16,000 dpi
Sensor Model	Roccat Owl-Eye
Polling Rate	1,000Hz
Programmable Buttons	6
LEDs	Two-zone RGB
Cable Length	6 feet
Weight	3.7oz

Corsair K95 RGB Platinum XT

Fully loaded doesn't begin to cover it

DAMN, this keyboard is terrible. The feet fold out sideways. That's vaguely neat from an aesthetic point of view, but the slightest lateral movement causes it to crumple to the deck with a whimper. Don't use the feet. They're really bad, and Corsair's engineers should flagellate themselves for designing them. Whether they choose to break out the birch twigs before or after they receive the plaudits for the rest of this keyboard is up to them. Damn, this keyboard is great.

The K95 Platinum XT is an obvious evolution of Corsair's tried-and-true overall design, which sees a cleverly folded aluminum base frame forming a neat dished base for the keyboard, with a distinct forehead and tiny, functional chin. Everything that isn't core keyboard (and there's a lot of that) has its own tactile distinguishing feature: the easy-to-find ridged buttons of the media cluster; the physically separated profile, lighting, and lock controls; the knurled, slick volume roller; and the macro column, which deserves further dissection.

Dedicated macro keys are divisive at best and a disaster at worst, particularly for those who locate their left hand by the feel of the left edge of the keys. Corsair has solved this problem: Not only are these keys colored differently, they're strongly textured, and they're contoured in the opposite direction from the Tab column—we didn't once, in a two-week testing period, accidentally hit G6 instead of Left Ctrl, and that's about the most ringing endorsement you're likely to find.

You have three options in terms of switches, one clicky (Cherry MX Blue) and two quiet: Cherry's luxurious Brown variety, or the Speed Silver variant tested here, the latter of which appears to be your only option if you pick up the alternate gunmetal finish. Switch performance is often very subjective. We've tried keyboards in which Speed Silver switches just didn't feel right, but Corsair has found the balance. There's a minimum of spring ring, and the rigidity of the base (and high actuation point of the switches) makes every keypress sharp and fast. Could the top of the keycaps be a micron smaller to prevent fat-fingered mispresses? Sure. Could the contour of the main key block be more favorable to help with accuracy when (curses) the K95 isn't lifted by its useless feet? Yes, yes it could. But we're not unhappy with the way this feels, and it's a keyboard that's sharp enough to help make the feeling-out period of flipping between keyboards as short as it can possibly be.

The "RGB" part of the name is so strong it deserves to be in 72-point bold. Per-key lighting burns through each keycap, and glows wonderfully in the gaps and through the clear bases of the switches. It's a feast for the eyes, made even more impressive by the 19-zone light bar along the rear, which beams color everywhere. Rainbow vomit isn't to everyone's taste, but this is equally capable of being subtle, and easily configured through Corsair's iCUE driver, and subsequently stored as one of five on-board profiles.

Even the little extras hit the mark. We often rag on Corsair for its brutal wrist rests, but this one swaps the horrible textured plastic for a soft, comfortable faux leather. There's a USB pass-through, running through a fat but sturdy feeling hard-wired braided cable. There are extra keycaps, textured examples to cover the WASD cluster, along with alternately colored "S" key, useful for marking keys you may have dedicated to the newly fostered Elgato Stream Deck integration of the macro buttons. It's a strong, strong package, and we have no doubt that it'll be resilient enough to last a great many years. That's handy, because damn, this keyboard is so expensive. It's worth it, but it's not the only great keyboard in the world. **–ALEX COX**

VERDICT **9**

Corsair K95 RGB Platinum XT

PLATINUM Feature-packed; great key feel; tons of well-executed extras.

FATINUM Terrible feet; pricey.

$199, www.corsair.com

SPECIFICATIONS

Switch Type	Cherry MX Speed Silver
Form Factor	Full size
Media Keys	Dedicated
Macro Keys	6x dedicated
LEDs	Per-key RGB with 19-zone light bar
N-Key Rollover	Full key, 100% antighosting
Pass-Through	USB 2.0
Dimensions	18.3 x 6.73 x 1.41 inches
Warranty	Two years

Razer Kraken Ultimate

Some iconic cans get the luxury treatment—and they're worth the extra outlay

THE LIME GREEN GLOW and marketing hyperbole of Razer's peripherals have been around since the earth's mantle first cooled and simple lifeforms began appearing. The Boomslang mouse was there at the turn of the millennium, when we first got interested in playing games *against other people,* live, on the Internet, and it remains as iconic as it is preposterously named.

Since those early days in the gaming peripherals market, the competition's heated up considerably, but Razer remains a big player thanks not just to quality mice, keyboards, and audio gear, but marketing and really, really fancy packaging. So, it's no surprise to see the $180 Kraken Ultimate headset arrive in a box covered in spot UV treatment and pithy slogans such as "Make sound your weapon." If anything, it's slightly disappointing not to be welcomed to "the cult of Razer" by the inner packaging, as the pre-Ultimate iterations of its headsets used to do, but we'll work past it. Its packaging is smartly presented; this is what we're trying to say.

So, too, is the headset itself, resplendent with an underglow of RGB around both earcups and a bright RGB Razer logo in the center of each one. Good-quality artificial leather surrounds two very generous memory foam pads around the contact points, and while the memory foam is actually quite thin under the headband, it's still very comfortable thanks to the band's broad dimensions. A Razer logo lies imprinted on the top of the headband, also finished in artificial leather, while an aluminum frame holds the whole unit together. At 14oz, it's not going for the featherweight category, but as silly as it may sound, it feels like a light 14oz when it's on your head. The cushioning is ample for glasses-wearers to maintain their spectacles while playing, and although this reviewer still prefers SteelSeries's ski-goggle headband design for long-term comfort, the Kraken is still up to the task when it comes to marathon sessions.

EXTRAS ORDINARY

For a model bearing the "Ultimate" nomenclature, it's a relatively barebones package—one 2m braided cable connects the headset to your PC via USB, and with no inline remote, the only controls are a volume wheel on the rear of the left earcup and a toggle switch for surround sound (don't bother) just above it. The mic mute switch is placed right on the mic itself, and a red light band clicks on when you do mute it. It's here where our only real misgivings lie—this is an expensive headset, and it's not working very hard to entice you with added extras. The cable's a bit short for our liking, and we can't get on with having to press the mic itself to mute it—often several times before we're sure it's actually muted. No, this is a headset that lives and dies on its comfort and sound quality alone.

Let's get to the heart of the matter: These cans sound incredible. For a long time, "50mm drivers" was marketing talk for "too much bass," but the custom-tuned neodymium 50mm monsters here have insane levels of clarity, which simply aren't diminished by all the low end. It's a brilliantly tuned tone, unsuitable for monitoring audio recording and the like—but that was never the point. Load up a game with explosions, crashes, gunfire, and/or raised voices, and there's no way you'll be disappointed.

What really stands out, though, is how well these headphones articulate music. There's a vibrancy higher up the EQ that lets you pick out details that might have previously been inaudible on other equipment, such as pick scrapes and voice cracks. And if you dare introduce any EDM with sub-bass in the mix to your ears, you'll hear just how meaty the low-end response is. And as much as Razer's bloated software suite makes you want to lambast it, even the mic sounds fantastic on this model, so we've simply no recourse to its virtues. **–PHIL IWANIUK**

VERDICT

9

KICK ASS!

Razer Kraken Ultimate

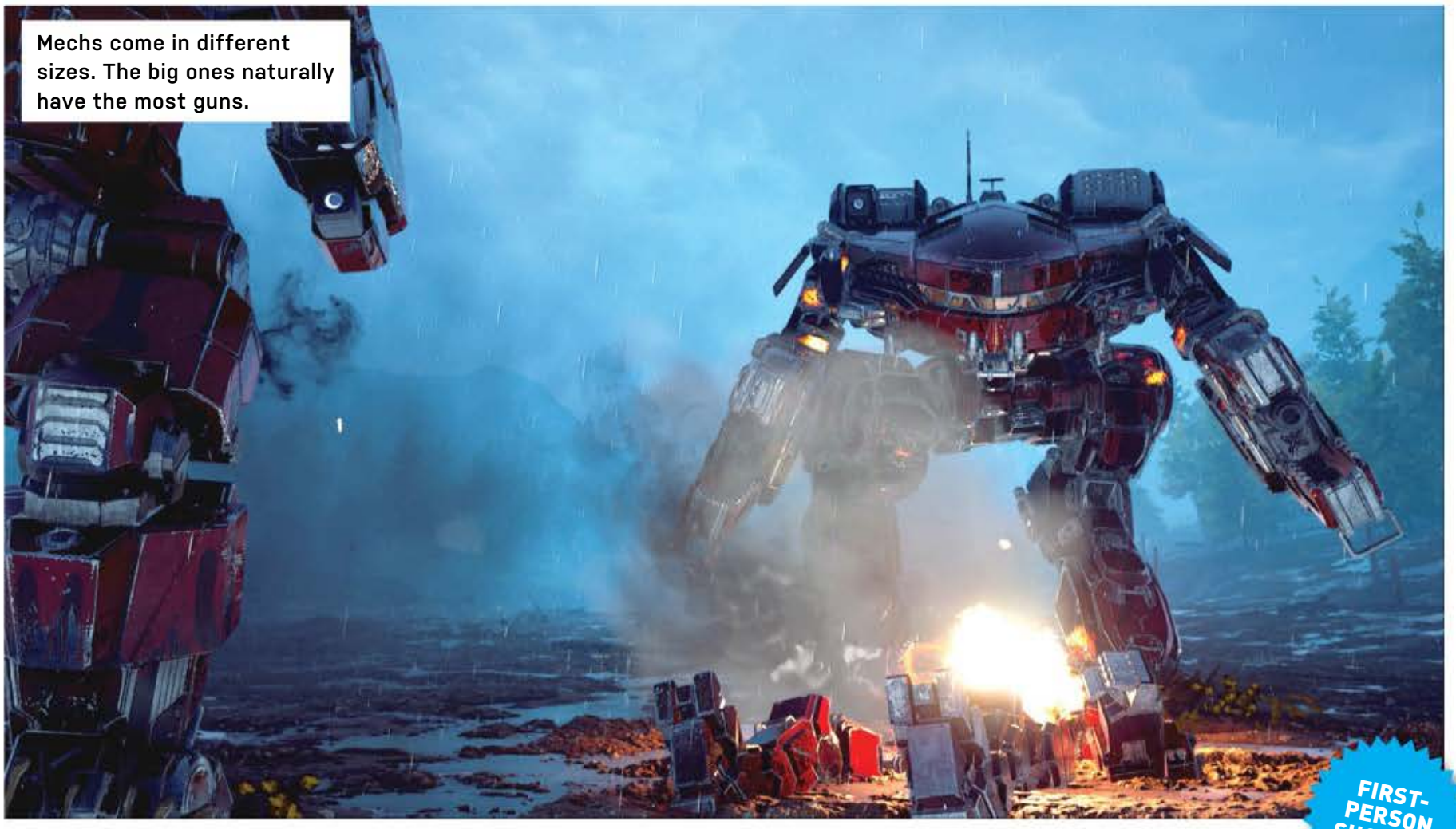
SQUIDS IN Booming low end; incredible clarity, smart design.

A RUM DO Short cable; awkward mic muting.

$180, http://razer.com

SPECIFICATIONS

Driver Type	50mm neodymium
Impedance	32 ohms
Frequency Response	20Hz–20KHz
Design Style	Closed back
Microphone Type	Noise-canceling electret condenser
Connectivity	USB
Weight	14oz
Cord Length	2 metres



Mechs come in different sizes. The big ones naturally have the most guns.

FIRST-PERSON SHOOTER

MechWarrior 5: Mercenaries

Meching good use of the things that they find

WE HAD TO CHECK, but it has indeed been 20 years since the last mainline *MechWarrior* game. *MechWarrior 4: Vengeance* (which, confusingly, had a standalone expansion called *Mercenaries)* was a first-person mech sim based on *BattleTech* in which you shot the limbs off enemy mechs to reach mission objectives and pick up the parts as scrap with which to augment your own stompy killing machine.

Little has changed in *MechWarrior 5,* apart from the fact the game now runs happily in 4K, supports ray tracing and DLSS, and you have the choice of a third-person view. You're a rookie pilot getting trained up when some bad guys attack, knock your father's mech off a cliff, and damage his mercenary outfit in search of something you know nothing about. It's a classic setup, forcing you to rebuild the unit and investigate what the attack was about before taking your revenge in an appropriately heavy metal manner. Your four-mech team can be filled out by computer players or real people online, and there's a lot to love about it as your pilot's hands mimic your inputs, and your mech roars into life.

Controller-users beware, however: the news that many PC gamers have eschewed keyboard and mouse for the console-owner's best friend has not reached Piranha Games. Sure, you can walk around, aim, and fire with thumbsticks, but you have to go back to the keyboard to do something like reset your torso rotation; so much, in fact, it's worth abandoning the controller and going back to WASD. There's an option to change it, but the throttle control by default increases and sticks there until you lower it. It's not always clear whether a stationary mech will lurch backward or forward either, thanks to torso rotation, and while you have free aim with the mouse, if you've rotated too far, your chest-mounted weapons can't come to bear on a target.

It gets more complicated when you're managing temperature, blaster ammo, jump jets, and armor. Keep your face toward the enemy while trying to get behind it to attack weaker rear armor, your legs going one way while your torso rotates and arm-mounted weaponry picks off aircraft coming in for an attack run, and you start to feel extremely powerful. Watch rocks fade into the ground as your mech stomps over them and you begin to wonder. Get damaged by fast-moving (but weak) tanks because your lasers are overheating and your AI teammates are happily walking into buildings, and you start to feel a bit silly.

Running your mercenary company adds a welcome layer of strategy, as you choose which solar systems to enter, which missions to take, how much salvage to bid for, and—eventually—which parts you actually need.

The glory of *MechWarrior 5* comes from blowing stuff up in the most efficient way, mixed with running a business on the side. It's undeniable fun to dodge through the battlefield in a light, fast mech, damaging heavier suits just enough to bring them down so you can pick them up later. It's also fun to use those salvaged bots, repaired and rearmed, to smash through enemy lines. But you may need to put some hours in first. **–IAN EVENDEN**

VERDICT **7**

MechWarrior 5: Mercenaries

MERCENARIES Huge stomping mechs firing lasers and missiles—what's not to like?

ADVERSARIES Graphics could do with a tune-up; voice accents verge on ridiculous.

RECOMMENDED SPECS Ryzen 7 1700/Core i7-6700K; 16GB RAM; GTX 1070/RX Vega 56.

$50, http://mw5mercs.com, ESRB: Not rated

© PIRANHA GAMES

Mission maps come in many different styles.

Headshots do a lot of damage, but don't always kill.

Back at base, you can train and equip your soldiers, who level up in battle.

Bullet placement is key to depriving enemies of their abilities.

STRATEGY

Phoenix Point

It's life, but not as we know it

COME INTO PHOENIX POINT unprepared, and you may accuse its devs of playing a lot of *XCOM.* This is almost certainly true, but beside the point. Snapshot Games has played a lot of *X-COM,* too, having been co-founded by Julian Gollop, one of the designers of the original *X-COM: UFO Defense* from 1994. As a result, *XCOM* veterans will find *Phoenix Point* familiar to the point of feeling like an expansion pack, but different enough to be thrilling. Anyone new to the series will find it a convenient place to get on, even if it doesn't quite hit the heights *XCOM 2* did.

This time, rather than arriving in flying saucers, the threat comes from the sea. Mutated creatures mixing human, seafood, and unknown DNA are wreaking havoc on the last bastions of humanity, and it's up to your rag-tag bunch of soldiers to blast them back into the water.

If you think you've seen that all before, check out the Geoscape, a draggable world map on which the locations of your bases, allies, and missions are marked. You transit this globe in your dropship, exploring, scavenging, and fighting. Kill some bad guys, and you can pick up their weapons, research them, and make your own. The bodies you recover can be autopsied for an increased understanding of your foe. There are bases to build, secrets to uncover, and alliances to broker, all while battling the undersea menace as it increases its incursions on to land.

Having a game that's so familiar means any changes stand out, so while *Phoenix Point* may be recognizable enough to play without tutorials, it can still catch you out. Manual aiming is top of the list: Gone are the *XCOM* percentages that would see your shotgun be 99 percent certain to kill an alien yet miss, in favor of two circles; 100 percent of your shots land in the larger circle, with 50 percent of them in the smaller, central one. Every shot is a simulated projectile rather than a probability, so if it looks like it will hit, it usually does. There are still chances to miss completely, such as your trooper fumbling his gun or a negative status effect throwing you off, but manual aiming makes things more certain.

Leaving shooting to your soldier means they target the enemy's center of mass rather than its discrete hit locations, and the value of being able to shoot the arms off a foe or cut its legs from underneath it means you'll be manual aiming almost all the time. This changes the game enormously, so you're more likely to take shots you'd shy away from in *XCOM 2.* It cuts both ways, though, with your soldiers just as likely to have their heads disabled by well-aimed enemy fire. Medikits heal hitpoints but don't fix disabled limbs—these are fixed when the mission ends, but hitpoints aren't, so you need to wait before the next mission or risk taking an under-strength team. It adds to the feeling of it being a massive balancing act.

It's not flawless—every time we fired up the game there was a clash between our latest local save and the one in the cloud, and it often opened a save with the map upside down, or focused on the other side of the world from our dropship. Annoyances aside, though, this is a strong game of strategy, tactics, and alien-shooting, and deserves to be more than "just another" *XCOM.* **–IAN EVENDEN**

VERDICT 7

Phoenix Point

BETTER Classic tactical gameplay with strategic layer.

WETTER Glitches can frustrate; graphics not that spectacular.

RECOMMENDED SPECS Core i5 3GHz/AMD FX series 3.2GHz; 16GB RAM; GeForce GTX 1060/Radeon R9 390X.

$40, http://phoenixpoint.info, ESRB: Not rated

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LAB NOTES

JARRED WALTON, SENIOR EDITOR

Help, I've Been Assimilated!

A lot has happened in the last five years

LIKE MOORE'S LAW, all good things must come to an end. I came to *Maximum PC* nearly five years ago, when most desktops were still limited to four-core/eight-thread processors, and the top enthusiast chip was the eight-core/16-thread Core i7-5960X. I arrived just in time for the GTX 980 Ti launch—my first GPU review for the magazine. It's been a wild ride, testing the latest and greatest hardware, and it's amazing to see how far we've come.

2015 was the year we got Intel's late-to-the-party Broadwell desktop CPUs, which became effectively obsolete just two months later with the arrival of Skylake. Dream Machine took us to the moon with four Titan X (Maxwell) GPUs, the i7-5960X, 64GB RAM, and a RAID 0 set of Samsung 850 Pro 1TB SSDs. That would still be a good PC, but 2020's kit not only performs better, but prices have plummeted.

Today, you could buy a Core i9-9900K for half the price of the old 5960X and get about 50 percent higher clock speeds. Alternately, for the same thousand-dollar asking price, Intel's Core i9-10980XE Cascade Lake-X CPUs are available with 18 cores, or you'll soon be able to go nuts with the Threadripper 3990X, packing a whopping 64 cores. For the GPU, the old Titan X is about as fast as today's GTX 1660 Super, and SLI is basically dead. Oh, how the mighty have fallen. The SSDs are still plenty fast, but instead of $640 for a 1TB SATA SSD, today you can get a much faster 1TB M.2 drive for about $150. 64GB of RAM is still more than you'll find inside most PCs, at least....

I'm not totally gone from *Maximum PC*—you'll still see me in "Tech Talk." I'll be joining our sister website Tom's Hardware, covering—yep—GPUs and graphics. 2020 should be an exciting year for that market.

CHRISTIAN GUYTON

Staff Writer

We're truly in a glorious new age of streamed entertainment media, aren't we? Gone are the days of going to the store to buy DVDs, gone is the time of borrowing from your audiophile friend's CD collection. Watching four episodes of *The Witcher* with zero adverts being pushed in your face is glorious (no, this totally isn't based on real events). However, it seems as though gaming just hasn't quite caught up yet. Stadia has been on the market for a while now, and I think I speak for the whole *Maximum PC* team when I say that it gets a resounding "eh." At the time of writing, there are fewer than 40 games available on the platform, most of which have to be purchased from the Stadia store, and the pricing isn't great. It's no Steam, that's for sure.

There's a certain divide between Google's Stadia and streaming services for other forms of media. For instance, I don't need to buy any new hardware to use Prime Video or Spotify; they work directly with the TV and smartphone I already own. But for Stadia, I'm expected to drop over 100 dollars on hardware first? Not for me, thanks.

There's always Stadia Pro, right? Ten bucks a month for two free games a month. One of the recent games is free-to-play on other platforms, actually. Cheaper than Netflix, but if Netflix only gave me two shows a month and one of them was on YouTube, I'd be reconsidering my subscription.

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Editors' Picks:
Digital Discoveries

Hardware staff writer, Joanna Nelius, and executive editor, Alan Dexter, reveal what has been keeping them in a spin

NZXT KRAKEN Z63

Sorry RGB lighting, but I have a new cosmetic obsession: The customizable LCD screen on NZXT's new Z-3 series AIO coolers. The screen is 2.36 inches and can display 24-bit color. With NZXT's CAM software, you can program it to display vital system data, such as temperatures, a photo, or your favorite animated GIF. The company recently added a few new models to its Kraken line-up, the X-3 series in addition to the Z-3 series, but the while the X-3 doesn't have LCD screens, both series feature a rotating pump or infinity mirror to keep the NZXT logo or custom image upright.

You pay a premium for this tech—$100 more than the equivalent X-3 cooler—but it's just too darn cool not to splurge on.

Also, the Z-3 series has been outfitted with a new Asetek pump, which provides better cooling and is quieter. Other than being nit-picky about the vertically facing logo on my current Kraken X52 (AIO coolers have different mounting brackets for AMD motherboards), it's a bit noisier than I would like. But the Z-3 series fixes both of those problems and has a customization option way better than any RGB-lit component or accessory.

$250, www.nzxt.com

LITEON ES1 ULTRA-SLIM DVD WRITER

I've recently decided to reclaim the shelf space given over to a sizable DVD collection. Like everyone else, my family increasingly watches movies streamed from Netflix and Amazon, rather than reaching for discs. Basically, there's not much call for an extensive DVD collection now, and the space it takes up could be put to better use.

The plan is to store the collection in the attic, after ripping it all to a NAS first. I may have only watched a handful of these discs in the last few years, but the urge to play the original cinema release of *The Empire Strikes Back* will undoubtedly rear its head the second it's no longer easy to do.

There's a problem: the trend in case design that's seen optical drives expunged from the PC's makeup. The answer was to grab an external DVD drive and rip the DVDs that way. A trip to Amazon netted me this LiteOn drive for just $20, which has performed its function flawlessly. It's quick, quiet enough, and is powered by the USB cable, so can hit the road with me if needed. It even came with a copy of Nero burning software, which I completely forgot existed. Now, if you'll excuse me, I've got a couple hundred DVDs to rip....

$20, www.liteon.com

Razer Hammerhead True Wireless Earbuds

WIRELESS EARBUDS are a curious proposition for a gaming brand. For starters, they're wireless, which puts some gamers off due to the potential for audio latency. And they're earbuds. Razer is a gaming brand; over-ear headphones are usually the way to go.

So the Hammerhead earbuds are a strange option, supposedly more for gaming purposes than the comparable AirPods. But it doesn't matter how strange it is, because these earbuds are seriously good. The custom-tuned 13mm dynamic drivers push incredible sound quality directly to your ear holes, with crystal-clear high notes and thumping bass that we'd have thought impossible in such tiny earphones.

They're controlled by tiny touchpads that take the appearance of the iconic green Razer logo, with small taps and holds for commands such as pausing music and adjusting volume. They're also voice assistant enabled, allowing you to use Siri, Alexa, or Google Assistant via the surprisingly good mic. It's fine for hands-free calls, but due to its omnidirectional pickup pattern, a separate mic is best if you want to use voice chat while gaming.

The latency is near-unnoticeable at 60ms. Mobile gaming is a potentially great avenue, as the carry case is easy to slip into a pocket. Like an AirPods case, it charges the earbuds, which snap into it via concealed magnets. Even if you're not a gamer, these are a high-quality pair of buds and far cheaper than Apple's solution.**–CG**

$100, www.razer.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Virtuoso VR
> ARMing Windows
> Dropbox Limitations

More VR

Thank you for publishing a dedicated VR issue (I suggested this in my previous email). I have a few more suggestions: You used to have a dedicated column named "Games that our staff play now" or something like that. Can you continue this good tradition, and maybe add VR games, if any? Can you do a gaming laptops feature some time soon, and add external soundcards, headphones, and other peripherals in review?

–Alec Kravt

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: Glad you enjoyed the feature; it was definitely time to catch up on the state of the industry, and it happened to coincide with Valve's announcement on *Half-Life: Alyx.* When it comes to your suggestion on what we're currently playing, this is what many of us cover off in the "Lab Notes" pages. There's nothing to stop us talking about VR there, although I suspect that the coverage of VR won't change too much, as no one in the office can be bothered to setup the VR gear currently languishing in our hardware cupboard.

There is some good news for you, though, and that is a feature on the state of mobile gaming, including peripherals. Expect to see something on this soon.

Too Many Cores?

I wanted to write in response to Jarred Walton's article, "AMD Ryzen 9 3950X," January 2020, where he mentioned the state of computing. I have an Acer notebook from 2014 that does the computing I wish to do. Granted, it "is for typing articles and minor image editing," but at this time, I don't need anything more powerful. Whether I will need a 16-core processor anytime soon is debatable. One can never tell when my notebook decides to "go south"! I consider myself to be a computer experimenter, but $750 is out of my price-paying ability. I would really enjoy having such a processor, and am sure I could use it for machine learning and other artificial intelligence work, rather than for gaming, as an Intel Core i9 outshines even this high-end second-gen 3000 series processor.

–Murray McCullough

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: It's fair to say that the likes of the Ryzen 9 3950X are absolutely overkill for most normal computing tasks, but that isn't really what it's for. As the price suggests, this is a serious chip for serious applications. And as we move over to systems having more cores, developers should start to use them more and more—so it shouldn't just be rendering and video editing that makes use of all those cores. As for gaming, it's true that Intel has the edge here, but if you're dropping this much cash on a processor, you're probably gaming at higher resolutions, in which case, that edge gets very slim indeed. So, while we agree that this is a chip more for tomorrow than for today's computing, if you're building a machine to last for years, it should be on your wishlist.

ARMing Up Windows

Sometime in 2020, perhaps a few words could appear regarding Microsoft's move to ARM processors. Will gaming eventually move to ARM processor-based PCs? Will this new architecture run Windows 10 for ARM or Android? Will major Windows 10 apps need to be ported over to work on the new platform? **–Terry M**

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: Microsoft's support for ARM has been something we've been monitoring and talking about for years, but with the release of the Surface Pro X, there's finally something concrete to talk about. It's fair to say that there are problems with actually running apps at launch, but it's in Microsoft's interest to resolve that, so we're optimistic about the future.

Positive VR

The state of virtual reality is obviously subjective, but I felt your article on the current market was not very informative and somewhat negative. VR is quite alive in really cool ways, such as racing drones, racing games, and flight simulators. IMHO, VR is the best thing

↘ submit your questions to: comments@maximumpc.com

to happen to simulation and FPV drones (I am not into games). For example, if you look at flight simulation, even Microsoft has decided to get back in the game shortly, and VR will be required.

Another thing about flight simulation is there is no such thing as a maximum PC. More power means more realism, and today's computers can't keep up with what the software can do. I run 2K per eye in VR, and it is great. I can't turn on all the features, because my GTX 1080 Ti can't keep up.

Try flying a real drone in VR and tell me it isn't great. This technology goes beyond PCs, but it is groundbreaking for some uses and is getting better. 2.5 HD screens in each eye is amazing. **–Bill Cullen**

STAFF WRITER, CHRISTIAN GUYTON, RESPONDS: It's fair to say that VR does have applications beyond gaming, and personally we'd love to see the VR market improve and broaden. There are a few reasons why we didn't discuss topics such as drones, though: The global market for drone racing (not exclusively VR drones, either) is currently valued around two billion US dollars, while the VR gaming market was valued at over 10 billion in 2018, and has far higher predicted growth. Similarly, the flight simulator market is valued around four billion USD, but the majority of that isn't in consumer software.

There's also the question of cost. One of our biggest issues with VR is the initial buy-in price, which needs to come down as the global divide between the rich and poor widens if VR is going to truly become a widespread technology. Add a powerful system and a good-quality racing drone or flight sim software on top of that, and VR becomes a difficult area to break into for many people.

We agree that the potential is there for some really awesome stuff as both VR and PC hardware improve, and we genuinely would like to see VR implemented in more areas, but right now it feels like it hasn't quite reached the place it needs to be.

Dropping Boxes

In the January 2020 issue, there is a short article on setting up Dropbox. It notes the 2GB limit for the free account, but it misses a much more significant limitation: The free account can only have three devices (PCs or phones) running Dropbox. Dropbox rolled out this policy change in March 2019. Existing free users were grandfathered in, but if an existing user tries to set up Dropbox on a new device, they have to reduce their installations to just three devices at that time.

I had Dropbox on five devices, and a new laptop for Christmas ultimately forced me to move to OneDrive, since I couldn't set it up with Dropbox, and I didn't want yet another monthly subscription to something that I'd have to keep, essentially, for life. I don't like OneDrive as much, but we own a small business that has the full version as part of Office 365. It works fine.

BTW, I've been a subscriber since *CD-ROM Today* folded into *boot*, which became *Maximum PC*. Probably been a subscriber since before many readers were born!

–Mark Gottschalk

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: While this won't affect everyone, it's still a good point that's worth highlighting, because depending on your setup, you can smash through the three-device limit quite easily (although with five devices, keeping under the 2GB can be a stretch as well). Ultimately, this may push you away from the free version of Dropbox—either calling on you to subscribe (and we absolutely understand your reluctance here), use an alternative, or configure some kind of workaround. One option is to use a different email address for your mobile devices; although this does mean that not everything is the same place, this may be preferable, depending on how you use your various devices. Here in the office, we find ourselves relying on Google Drive more and more, because it has a 15GB limit and supports unlimited devices.

[READER SPOTLIGHT]

FIRST BUILD

I wanted to take a moment and thank you for the numerous articles that you've published over the years on building a PC. I've been an avid computer user since I was about 16 years old (my first computer was a Commodore 64), but yesterday was the first time that I built my own PC. Your magazine was extremely helpful in selecting components and building the PC. I also had to refer to a couple of YouTube videos from Newegg Studios and a young man named Joey Delgado for additional information, but your magazine is what inspired me and gave me the push in that direction.

I took my time with the build and spent about five hours from start to finish. I work as a design engineer in the automotive industry, so I probably spent too much time planning the cable runs, but they all worked out. By far the most difficult portion of the build was connecting the front panel connectors. Some of them were definitely not designed for man-size hands and fingers! I had to take a break and settle down during that portion of the build.

The computer didn't boot on the first start-up, but the Asus motherboard had an LED light, which indicated that something was wrong with the memory. I remember reading several articles in your magazine that this is a common mistake with new builders, and your remedy was spot-on: The memory wasn't seated properly. The second start-up went fine. I also didn't have to access the BIOS and modify the boot drive, because the computer went right to the flash drive to install Windows 10. **–Scott Cortese**

Here are the specs of my new build:

Case: **Corsair Carbide 175R**
PSU: **Corsair RM750x**
Mobo: **Asus ROG Strix Z390-E**
CPU: **Intel Core i7-9700K**
Cooler: **Noctua NH-U12S**
GPU: **Asus ROG Strix GeForce RTX 2060 6GB**
RAM: **Corsair Vengeance LPX 16GB DDR4 3000**
SSD: **Samsung 970 EVO PLUS M.2 2280 1TB**
HDD: **WD Black 1TB**
Fans: **Corsair ML120 (x3)**
OS: **Windows 10 Home 64-bit**

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THE BUILDS

BUDGET

INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$63
PSU	Thermaltake Smart Series 80+ 430W NEW	$36
Mobo	Gigabyte B450M DS3H NEW	$68
CPU	AMD Ryzen 5 2600	$120
GPU	EVGA GeForce GTX 1660 Super Black 6GB	$230
RAM	8GB (2x 4GB) Patriot Viper 4 Blackout Series @ 3,200MT/s NEW	$44
SSD	120GB Adata SU650 SATA III	$23
HDD	1TB Western Digital RE3 WD1002FBYS NEW	$28
OS	Ubuntu Desktop Linux 18.04.3 LTS 64-bit	$15

Approximate Price: $627

WE'RE MAKING QUITE a few changes this month. First (forgive us for not going down the list in order) is the HDD, which we're changing in both the Budget and Mid-Range builds. The cheap Seagate drive we had been using is no longer quite so cheap, so we're swapping to a different manufacturer, but keeping the product more or less the same. It's still a 7,200 rpm hard drive with 1TB of capacity. We tweaked the RAM by a similarly small amount, swapping from Patriot's Viper Steel memory to the Viper 4 Blackout to save a few bucks. Bigger changes came in the form of a new PSU, Thermaltake's Smart 430W model, and a manufacturer change for the motherboard, sticking with the B450M format, but swapping to Gigabyte's budget model. Everything else stuck around in terms of price; the Ryzen 5 2600 still comes with three free months of Xbox Game Pass, so snap that up.

MID-RANGE

INGREDIENTS

PART		PRICE
Case	Fractal Design Meshify C	$85
PSU	500W EVGA 500 BR 80+ Bronze	$55
Mobo	Gigabyte X570 UD NEW	$140
CPU	AMD Ryzen 5 3600X	$205
Cooler	AMD Wraith Spire	N/A
GPU	XFX Radeon RX 5700 8GB	$330
RAM	16GB (2x 8GB) G.Skill Aegis @ 3,200MT/s NEW	$65
SSD	500GB Sabrent Rocket M.2 PCIe SSD	$110
HDD	1TB Western Digital RE3 WD1002FBYS NEW	$28
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,118

REJOICE! THE ASROCK X570 PHANTOM GAMING 4 is finally no longer on sale, and a new contender has risen to claim the "cheapest X570 motherboard" crown. The king is dead, long live the king, etc. It's Gigabyte once again, with its X570 UD board—fairly similar to the outgoing mobo, really. There's not too much else to be changed here, what with the Ryzen 5 3600X on sale for a staggeringly low $205; nobody's beating that price. We considered using that spare cash to make a big upgrade here, but ultimately decided to leave it for now. Remember that next issue, when the price of this build jumps back up over $1,200. We're trading out our memory for G.Skill's Aegis line, sticking with 16GB and 3,200MT/s to keep our performance in line without letting the price rise. Lastly, we're making that same change as the Budget build, replacing our Seagate drive with Western Digital's 1TB RE3 model.

UPGRADE OF THE MONTH

MSI GEFORCE RTX 2080 SUPER VENTUS 8GB

Six hundred and eighty bucks!? It's almost ridiculous how good value this model of Nvidia's excellent RTX 2080 Super is. This is the card that makes 4K gaming more viable; or 1440p ultra, with ray tracing on. Don't get us wrong, it's still a lot of money for a GPU, but right now it's hard to recommend anything else for powerful gaming systems. With 8GB of VRAM at 15.5Gb/s and a tasty 1,830MHz boost clock, this is a powerhouse card that is edging closer and closer to half the price of its big brother, the still-ludicrously-expensive RTX 2080 Ti. It's great, and it's never been better value.
$680, http://msi.com

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THE RTX 2080 SUPER GPUS are still dropping in price, almost alarmingly so. But we're not complaining; $680 for the 2080 Super Ventus from MSI is a fantastic deal that we recommend to anyone building a high-end system. We've made a few changes to our Turbo build this issue, starting with a shift over to Gigabyte's X399 motherboard—the Asus Prime model we had last issue leapt back up in price—and another memory shift, going to G.Skill's Ripjaws V memory, but sticking with the same specs. Hopefully soon we'll be able to buff up the memory in these systems.

We've also changed up the cooling. We're sticking with AIO, of course, with a three-fan radiator to deal with the Threadripper's heat generation. Specifically, we're using Enermax's Liqfusion 360, a solid AIO cooler with some sweet-looking RGB ring fans and an illuminated water block. It's a great, inexpensive cooler that comes with a little RGB controller, or can be synched with your ARGB software of choice. The Turbo build has also been peeking at the Mid-Range's notes, as we're going with Sabrent's 1TB model of its Rocket SSDs, currently on sale. At the time of writing, it's the cheapest 1TB M.2 drive that can hit those kick-ass fourth-gen PCIe write speeds, and we can't recommend it enough. You can skip the slightly pricier model that comes with a heatsink, as the X399 Aorus Pro mobo comes with a heat shield for an M.2 drive.

For more of our component recommendations, visit www.pcgamer.com/hardware/buying-guides/

INGREDIENTS

PART		PRICE
Case	NZXT H700i	$170
PSU	850W Corsair RM850 80+ GOLD	$128
Mobo	Gigabyte X399 Aorus Pro **NEW**	$316
CPU	AMD Threadripper 2950X	$690
Cooler	Enermax Liqfusion 360mm ELC-LF360-RGB AIO **NEW**	$110
GPU	MSI GeForce RTX 2080 Super Ventus 8GB	$680
RAM	32GB (2x 16GB) G.Skill Ripjaws V Series @ 3,600MT/s **NEW**	$140
SSD	1TB Sabrent Rocket NVMe M.2 PCIe SSD **NEW**	$180
HDD	2x 3TB Seagate BarraCuda Compute HDD	$160
OS	Windows 10 Home 64-bit OEM	$100
Approximate Price:		**$2,674**

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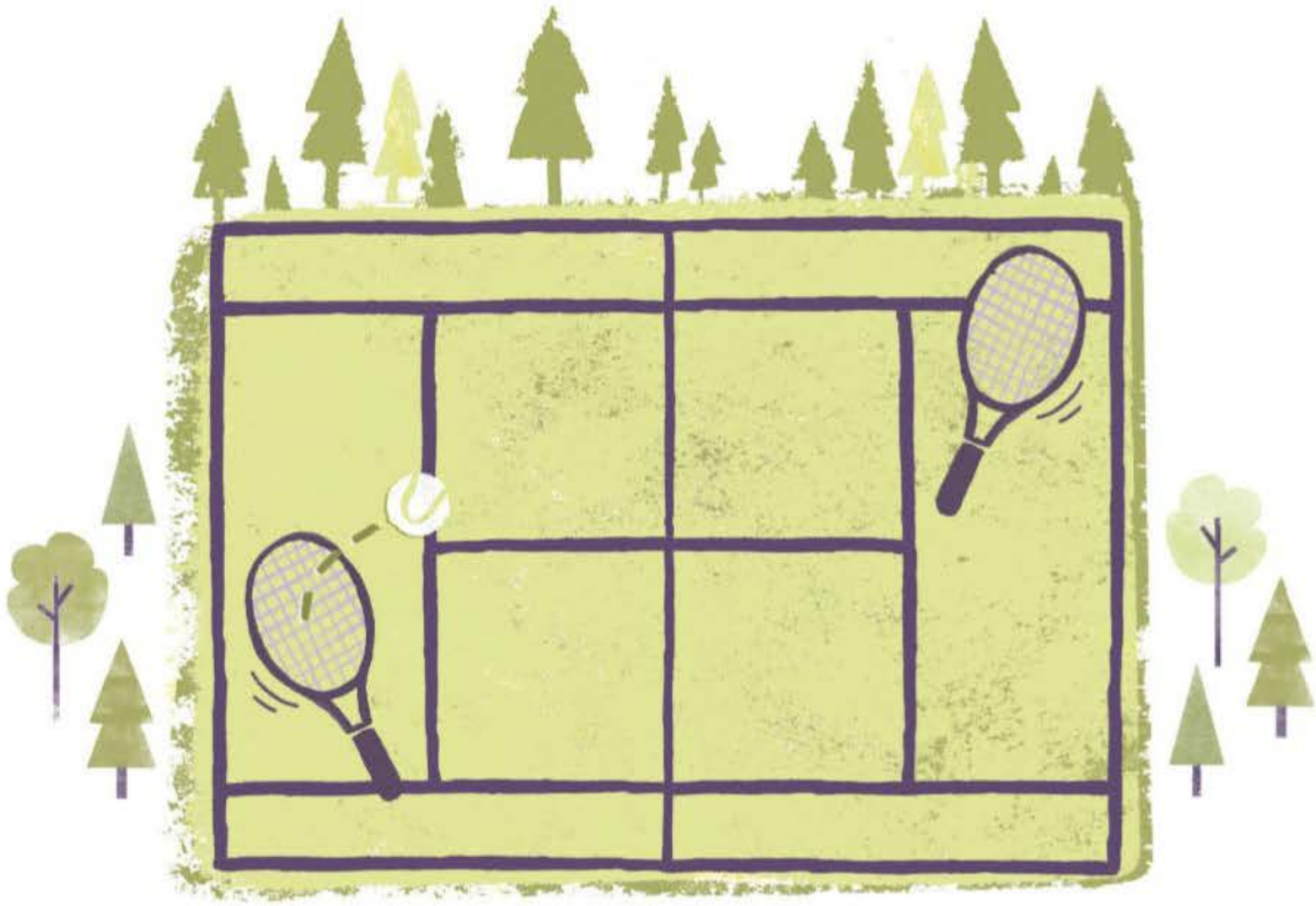

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